2008

NASA Range Safety Annual Report

This 2008 Range Safety Annual Report
is produced by virtue of
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I. INTRODUCTION

Welcome to the 2008 edition of the NASA Range Safety Annual Report which was funded by NASA Headquarters, Office of Safety and Mission Assurance (OSMA). This report was generated per NPR 8715.5 and provides a NASA Range Safety overview for current and potential range users. This year, along with full length articles concerning various subject areas, we have provided updates to standard subjects with links back to the 2007 original article. Additionally, we present summaries from the various NASA Range Safety Program activities that took place throughout the year, as well as information on several special projects that may have a profound impact on the way we will do business in the future.

The sections include a program overview and 2008 highlights of Range Safety Training; Range Safety Policy; Independent Assessments and Common Risk Analysis Tools Development; Support to Program Operations at all ranges conducting NASA launch operations; a continuing overview of emerging Range Safety-related technologies; Special Interest Items that include recent changes in the ELV Payload Safety Program and the VAB explosive siting study; and status reports from all of the NASA Centers that have Range Safety responsibilities.

As is the case each year, contributors to this report are too numerous to mention, but we thank individuals from the NASA Centers, the Department of Defense, and civilian organizations for their contributions. We have made a great effort to include the most current information available. We recommend that this report be used only for information and that the validity and accuracy of all articles be verified for updates.

This is the third year we have utilized this web-based format for the annual report. We continually receive positive feedback on the web-based edition, and we hope you enjoy this year's product as well.

It has been a very busy and productive year on many fronts as you will note as you review this report. Thank you to everyone who contributed to make this year a successful one, and I look forward to working with all of you in the years to come.

Rich Lamoreaux
NASA Range Safety Manager

II. AGENCY RANGE SAFETY PROGRAM OVERVIEW AND 2008 HIGHLIGHTS

2008 was one of our busiest and most exciting years in Range Safety. Before we highlight the areas covered in this year's edition, it is important to restate the goal of the NASA Range Safety Program. The program is defined in NPR 8715.5, dated 8 July, 2005, and is authorized by the NASA Administrator. The goal of the program is to protect the public, the workforce, and property during range operations such as launching, flying, landing, and testing launch/flight vehicles. This goal applies to all centers and test facilities and all NASA vehicle programs including expendable launch vehicles, reusable launch vehicles, unmanned aerial systems, the Space Shuttle, and the Constellation Program. Also included in this group are NASA-funded commercial ventures that involve range operations. We meet the goal of NPR 8715.5 by evaluating, mitigating, and controlling the hazards associated with range operations such as debris, overpressure, and toxics. With that in mind, we continued our effort to do a line-by-line review of the NPR, identifying areas in need of updating and suggesting additions in an effort to strengthen the policy arm of NASA Range Safety.

This is the third year we have gone with a web-based format, which continues to evolve, and our outline remains mostly unchanged from last year. However, we have incorporated one major change in our approach to updating articles: instead of repeating standard article information, we have decided to include updates only and provide links back to the original articles. We hope this will provide a more user-friendly format. Several areas of range safety will be covered that demonstrate how we meet or implement the Range Safety Program. A primary focus is training and our continuing efforts regarding the NASA Range Safety Training Program.

We remain extremely busy in the development, implementation, and support of range safety policy. The Constellation Program is in full swing, and we have been supporting tailoring exercises with representatives from the Program, the 45th Space Wing, and the Launch Constellation Range Safety Panel for both Ares I-X and Ares I. Additionally, we supported several launches this year and continue to work updated agreements with our partners at the Eastern and Western Ranges.

NASA Range Safety personnel continue to support the Range Commanders Council meetings and have been involved in updating policy related to flight safety systems and flight safety analysis. A recap of these efforts is highlighted. We address our continued support to the Common Standards Working Group in an effort to codify updates to AFSPCMAN 91-710, 91-711, and 91-712 requirements for Reusable Launch Vehicles. Unmanned Aerial Systems (UAS) policies development for operations at the Eastern Range is discussed, as well as continuing efforts regarding several challenges that we faced in the flight safety systems realm this year.

Additionally, we continue to support HQ-sponsored Infrastructure, Facilities, and Operations (IFO) Audits, and we provide a synopsis of inspections conducted at Wallops Flight Facility and Ames Research Center. The plans for the development of a common risk analysis tool for all NASA Range Safety efforts was an area of particular interest this year, and we discuss this effort in depth. We also address launch operations at KSC, the Eastern and Western Range, DFRC, WFF, and Reagan Test Site.

Emerging range safety technology continues to interest many in the range safety community. Several articles focus on efforts in this area that have taken place over the past year.

We once again provide insight into some special interest items, specifically regarding the effort to obtain a signed ELV Payload Safety NPR and VAB explosive siting for Constellation processing.

As always, we will conclude with range safety reports from the NASA Centers that were actively involved with range safety issues throughout the year.

A. AGENCY RANGE SAFETY TRAINING 2008 UPDATE

To date, 490 students have taken part in 19 Range Safety Orientation Courses. Breaking participation down by course subject, 83 students participated in 5 Flight Safety Analysis courses, 65 students participated in 4 Flight Safety Systems courses, and 18 students participated in 3 Range Safety Operations courses. The schedule for all courses in 2009 is depicted in Figure 1 below.

For more background and information on Agency Range Safety Training, *click here.*

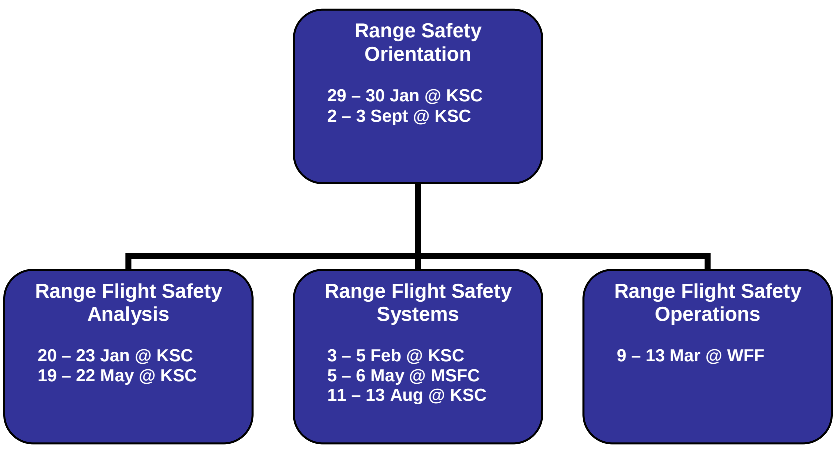

FIGURE 1: 2009 COURSE SCHEDULE

1. Range Safety Orientation Course

The Range Safety Orientation Course, as outlined in Figure 2, is designed to provide an understanding of the range safety mission, associated policies and requirements, and NASA roles and responsibilities. It introduces the students to the major ranges and their capabilities, defines and discusses the major elements of range safety (flight analysis, flight termination systems, and range operations), and briefly addresses associated range safety topics such as ground safety, frequency management, and unmanned aerial systems (UAS). The course emphasizes the principles of safety risk management to ensure the public and NASA/range workforces are not subjected to risk of injury greater than that of normal day-to-day activities.

It is designed to inform the audience of the services offered by the Range Safety organization, present timeframes that allow adequate interface with range safety during Program/Project startup and design in an effort to minimize potential delays and costs, and recommend ways of making the working relationship with Range Safety beneficial for the range user. This course includes a visit to Range Safety facilities at CCAFS/KSC and will normally only be presented at the Eastern Range. If you wish to discuss presenting the class at your location, please contact the NSTC staff.

Target Audience:

- Senior, program, and project managers
- Safety, Reliability, Quality, and Maintainability Professionals with an interest in Range Safety activities

2. Range Flight Safety Analysis Course

The Range Flight Safety Analysis Course is designed to give the student a detailed understanding of range safety analysis. As depicted in Figure 3, it includes NASA, FAA, and DoD requirements for flight safety analysis; a discussion of range operation hazards, risk criteria, and risk management processes; and an in-depth coverage of the containment and risk management analyses performed for expendable launch vehicles (ELVs) at the Eastern Range. Although the course is based on ELVs at the Eastern Range, the overall analysis process and concepts are also applicable to other vehicles and other ranges. The course concentrates on debris hazards and analyses but also includes an overview of toxic, blast, and radiation risks and analyses. The course includes a class exercise that covers the entire analysis process.

Prerequisite: Prior attendance at NSTC Course 074, *Range Safety Orientation*, or equivalent experience.

Target Audience:

- NASA, FAA, and DoD Range Safety Analysts
- Range Safety personnel in other disciplines
- Program/project managers and engineers who design potentially hazardous systems to operate on a range

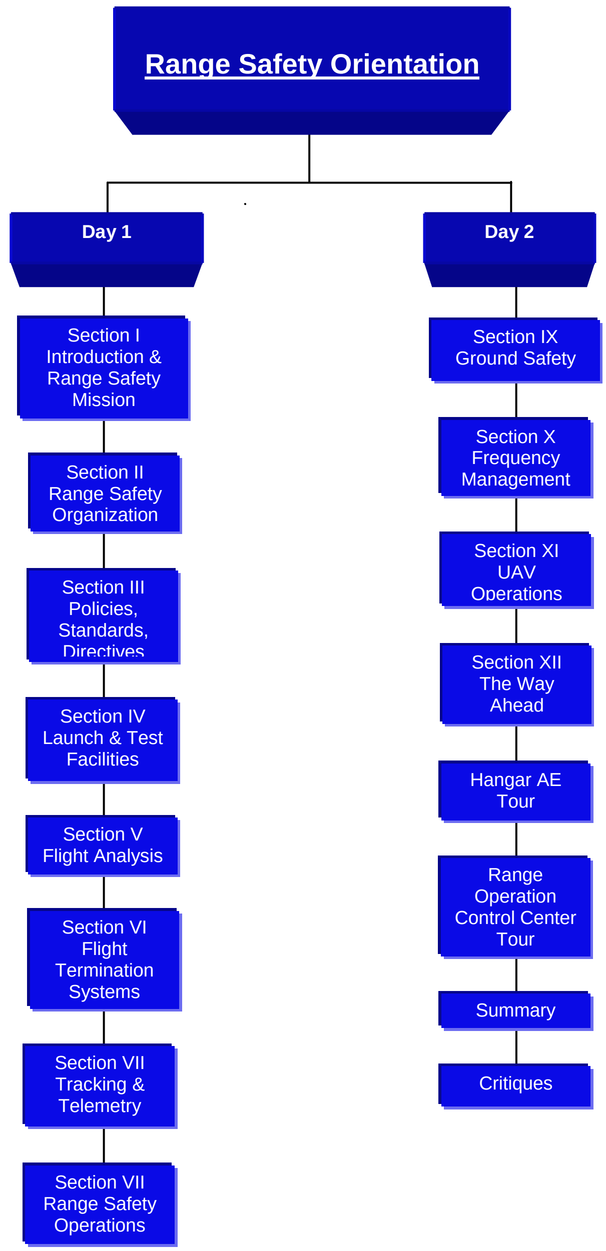

FIGURE 2: ORIENTATION COURSE OUTLINE

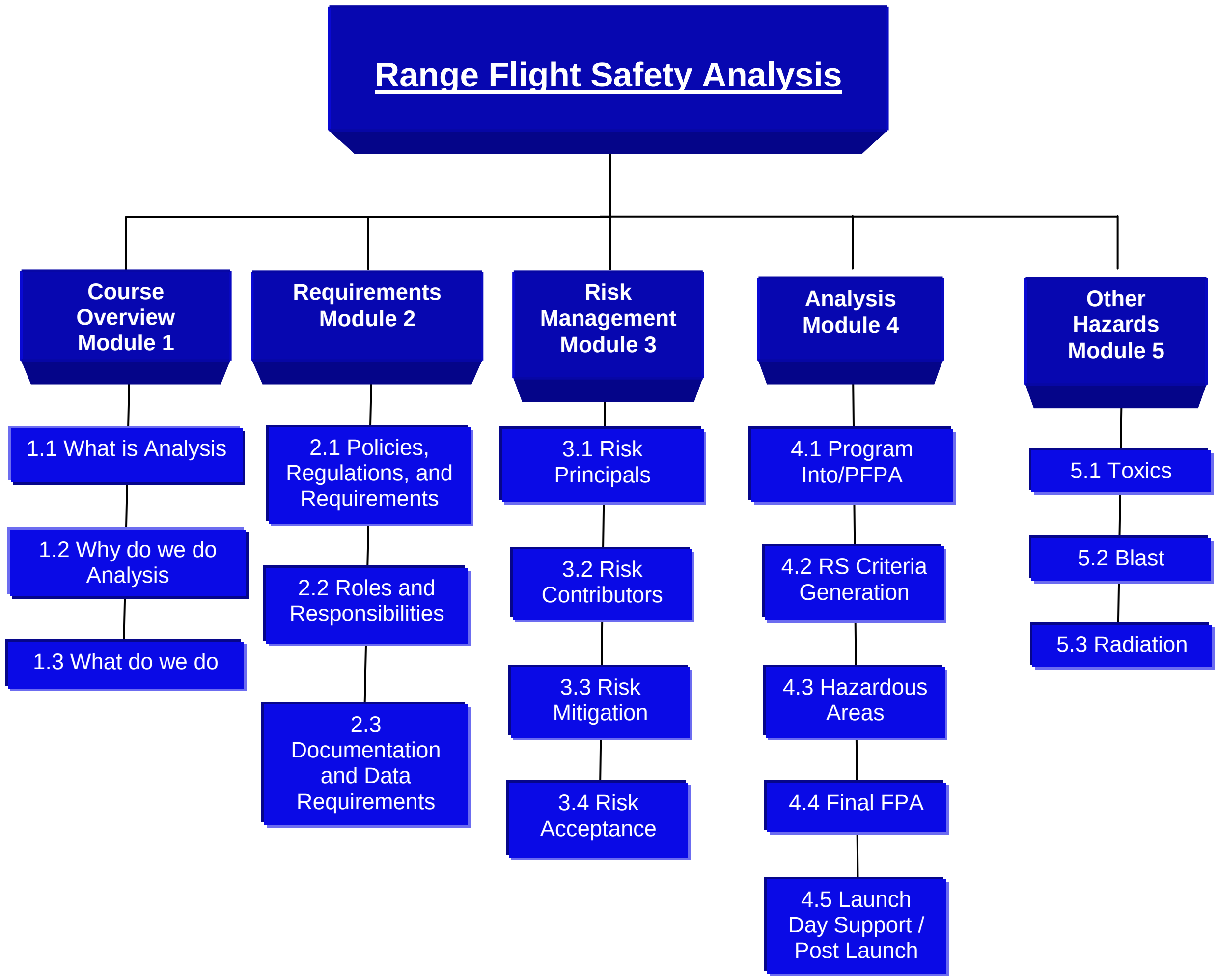

FIGURE 3: RANGE FLIGHT SAFETY ANALYSIS COURSE OUTLINE

3. Range Flight Safety Systems Course

This course describes required safety responsibilities and Flight Termination System (FTS) procedures and plans. It also includes FTS component design, performance, test, and subsystem pre-launch requirements (see Figure 4). The course then transitions to the applicable FTS ground support and monitoring equipment, FTS analysis, and component test history. The course continues with a review of unmanned aerial systems (UAS) flight termination systems, balloon universal termination packages, and the Enhanced Flight Termination System (EFTS). The class concludes with a description of the Autonomous Flight Safety System. The course size at KSC is limited due to tours we conduct at the Navy Trident trainer facility (located on CCAFS.)

Prerequisites:

- Completion of NSTC 074, *Range Safety Orientation*, or equivalent level of experience or training, is required
- Completion of NSTC 002, *System Safety Fundamentals*, or NSTC 008, *System Safety Workshop*, is recommended

Target Audience:

- NASA, FAA, and DoD Range Safety Personnel working Flight Safety Systems issues
- Range safety personnel in other disciplines
- Program/project managers and engineers who design potentially hazardous systems to operate on a range
- Personnel who conduct hazardous operations on a range

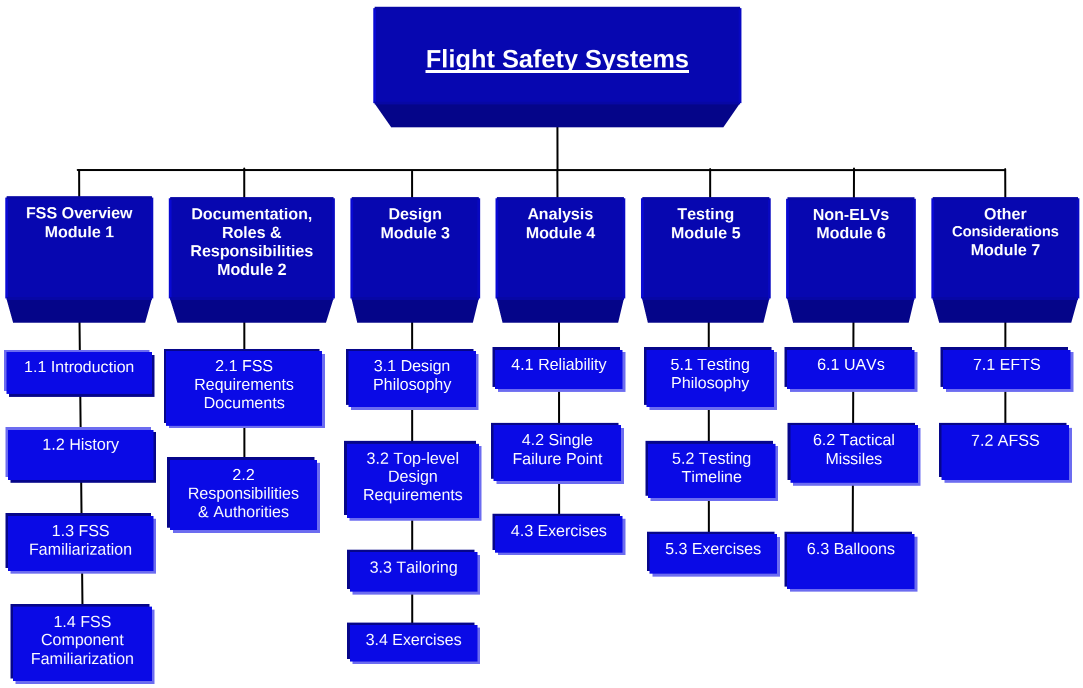

FIGURE 4: RANGE FLIGHT SAFETY SYSTEMS COURSE OUTLINE

4. Range Safety Operations Course

To ensure mission success and the safety of operations for the Range, a formal process has evolved within the range community to provide Range Safety operations. This course addresses the roles and responsibilities of the Range Safety Officer (RSO) for Range Safety operations as well as real-time support, including pre-launch, launch, flight, re-entry, landing, and any associated mitigation. Mission rules, countdown activities, and display techniques are presented. Additionally, tracking and telemetry, along with vehicle characteristics and sortie/range generation and checkout, are covered in detail. Finally, post operations, lessons learned, and the use and importance of contingency plans are presented. Those participating in the course receive hands-on training and exercises to reinforce the instruction. It is important to note that this course is only presented at WFF (Wallops Flight Facility) and is limited to six participants. The course centers on the topics shown in Figure 5 below.

Prerequisites:

- NSTC course 074, *Range Safety Orientation*, or equivalent experience and/or training, and a background in range safety.

- NSTC-0086; *Range Flight Safety Analysis*, or equivalent experience and/or training.
- NSTC-0096; *Flight Safety Systems*, or equivalent experience and/or training

Target Audience:

Persons identified as needing initial training for future/current jobs as RSOs with NASA or RSO management.

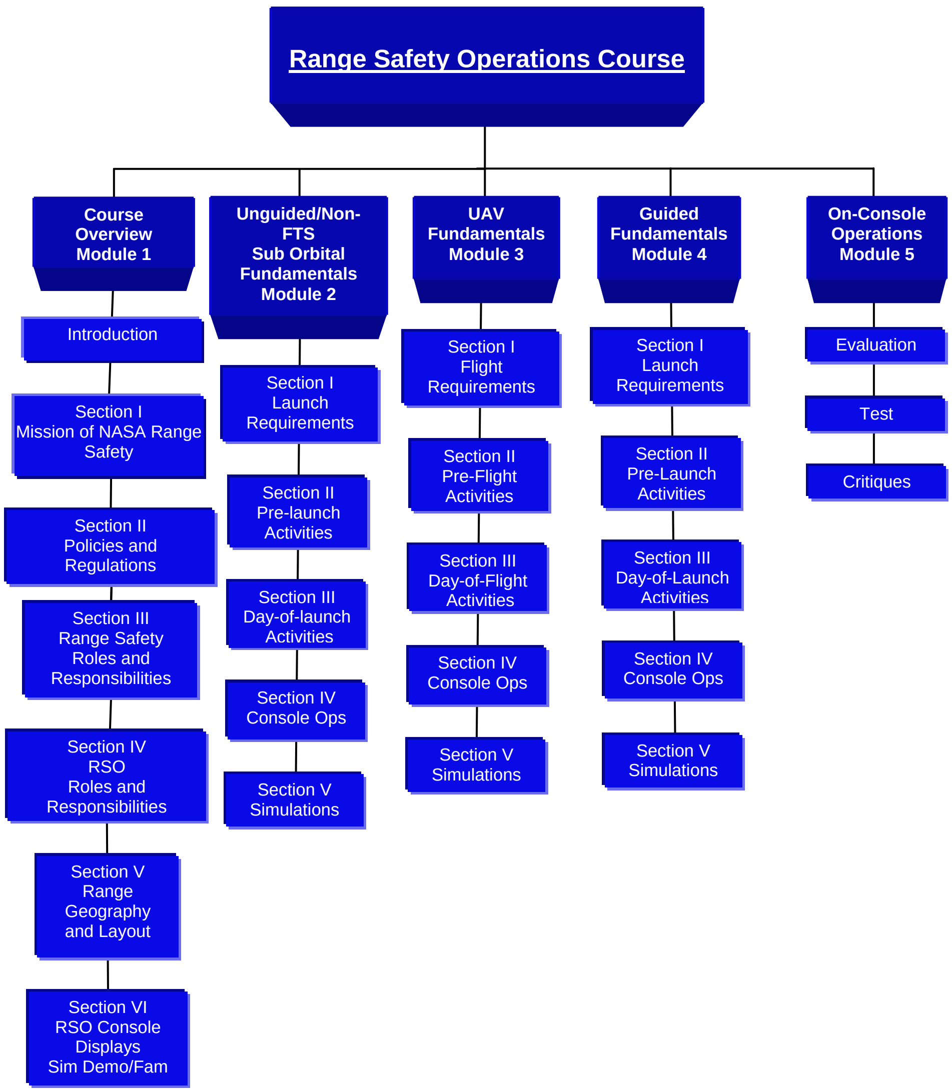

FIGURE 5: RANGE SAFETY OPERATIONS COURSE

If you wish to attend any of the courses offered, please contact your Center training manager, or refer to the NSTC web site course catalogue located at:

https://satern.nasa.gov/elms/learner/catalog/

B. DEVELOPMENT, IMPLEMENTATION, SUPPORT OF RANGE SAFETY POLICY

1. Constellation Tailoring

NASA Range Safety continued to support the Constellation Program in its efforts for a 2009 Ares 1-X test flight by tailoring range safety requirements with the 45th Space Wing and the Program. Since the Program is required to meet the combined requirements of NASA Procedural Requirements (NPR) 8715.5, *Range Safety Program*, and Air Force Space Command Manual (AFSPCMAN) 91-710, *Range Safety User Requirements*, we worked jointly to bring these requirements into one document, Cx 70155-01, *Air Force Space Command Manual 91-710 / NPR 8715.5 Range Safety User Requirements Manual Tailored for the Ares I-X Flight Test Vehicle Mission.* A version of the tailored Ares 1-X Range Safety Flight Test Vehicle Mission document is complete with final signatures from the KSC Center Director, Constellation Program Manager, and 45th Space Wing Commander. The new document codifies the philosophy of shared responsibility for all aspects of range safety between the 45th Space Wing and NASA and will serve as the foundation for future tailoring efforts between the two organizations.

Departures from current baseline requirements were documented via four range safety waivers. Although not the normal process, the team agreed after considerable discussion that this method was the most appropriate for documenting the noncompliances associated with the decision to incorporate heritage Shuttle Flight Termination System (FTS) components.

Development of a tailored document to support the Ares 1 launch vehicle has also begun. All of the FTS noncompliances with the AFSPCMAN 91-710 baseline are expected to be eliminated for Ares I. This document will also incorporate the philosophy of shared range safety responsibility between the 45th Space Wing and NASA.

Integral to both of these joint tailored documents is the Launch Constellation Range Safety Panel (LCRSP), which is the group responsible for range safety activities for elements of Constellation launch vehicle flights and preoperational test flights (e.g., Crew Launch Vehicle (CLV), Cargo Launch Vehicle (CaLV), and the Crew Exploration Vehicle (CEV), etc.). These documents are briefed through the LCRSP prior to final coordination and approvals by the KSC Center Director, Constellation Program Manager, and 45th Space Wing Commander.

For more background and information on Constellation Tailoring, *click here.*

2. NPR 8715.5 Revision

As NASA Range Safety continues to grow and mature, it became evident that our range safety requirements needed to do the same. In late 2007, we initiated an effort to revise our current NPR requirements document, NRP 8715.5, *Range Safety Program*, dated 8 July, 2005. To aid in this effort, an NPR Technical Interchange Meeting (TIM) was conducted in Colorado Springs, CO involving subject matter experts from NASA, Air Force Space Command, and the Federal Aviation Administration (FAA). The TIM yielded positive results with respect to commonality of requirements and updates to our range safety requirements.

We have spent the majority of 2008 vetting comments and coordinating deletions, updates, and language within our organization and NASA Headquarters. There have been a few challenges that we continue to work, such as noncompliance terminology, aggregate risk, and Unmanned Aerial Systems, to mention a few.

There is an ongoing discussion within NASA to utilize common terms and definitions associated with noncompliances, be it variance, deviation, waiver, or equivalent level of safety (ELS). We are working to ensure that these terms are consistent with other NASA procedural requirements documents and throughout all NASA programs. Both the Air Force and FAA use the terms waiver and ELS to identify noticeable or marked departures from requirements, standards, or procedures. Although these terms are commonly understood within the range safety community, they may not be consistently interpreted by other NASA programs.

Even before a Werner Von Braun-led V-2 rocket launched from White Sands Missile Range landed outside of its containment area just east of Alamogordo, New Mexico on 15 May, 1947, there have been questions with respect to the acceptable risk criteria for workers and the general public. Early in the space program, risks were largely unknown, and as a precaution, isolated areas were selected as launch sites to accommodate a public safety containment philosophy. As the space program has evolved, containment has become more difficult due to the increasing range populations and explosive potential of launch vehicles, encroachment of populations and municipalities around launch sites, and increased sensitivity to public risk. To help deal with these concerns, a risk management philosophy was adopted to help ensure people are not subjected to a risk of injury that is greater than that associated with normal day-to-day risk.

Today, NASA's risk criteria is expressed in terms of Probability of Impact, Probability of Casualty (Pc) (or individual risk), and Casualty Expectation (Ec) (or collective risk). These criteria can be applied per mission or annually but are always applied on a per hazard basis. These acceptable risk criteria have been in our NPR since its posting in 2005 and have been a community standard for many years. In 2006, the Range Commanders Council decided to transition from the collective risk criteria to an aggregate risk criterion to better encompass a combination of all risks associated with a mission.

Transitioning to aggregate risk will change how the range safety community and risk acceptors apply collective risk via the aggregate risk criteria. Individuals must not be exposed to a probability of casualty greater than 1E-6 for any single mission from all hazards. Collective risk for the general public now must not exceed a casualty expectation of 100E-6 (1E-4) for any single mission from all hazards. According to RCC 321, *Common Risk Criteria Standards for National Test Ranges*:

> Limiting the collective risk for the general public to 100E-6 (1E-4) expected casualties per mission ensures protection that is generally consistent with, or more conservative than, the previous limit of 30E-6 (3E-4) expected *fatalities due to inert debris.* Specifically, the typical ratio of fatality expectation to casualty expectation for the typical hazards indicate that the 100E-6 (1E-4) expected casualties criteria is likely to limit a range activity more than the previous limit, unless the range activity presents inert debris hazards only. For example, a launch with inert and explosive debris hazards and a risk estimate of 100E-6 (1E-4) expected casualties would typically correspond to about 25E-6 expected fatalities. So the 100E-6 expected casualty limit provides more protection than the 30E-6 expected fatality limit, particularly if toxic or DFO risks are significant. Thus, the current standard for expected casualties is rational: consistent with the previous expected fatality criteria from a safety perspective.

> This same ratio between the expected casualties and expected fatalities criteria for General Public is carried over the Mission Essential/Critical Operations Personnel categories and Annual criteria.

Additionally, there has been a move afoot over the past few years to transition from the term “uninhabited aerial vehicle (UAV)” to “unmanned aerial system (UAS).” The rationale behind this move is to focus on the entire system, encompassing the ground control station, remote control operators, computer systems, and the aerial vehicle, not just the aerial vehicle itself. In late 2006/early 2007, the FAA mandated the use of the term UAS when applying for a certificate of authorization (CoA) to fly in national airspace. Based on that mandate, the DoD was the first agency to comply and has fully integrated the term into its programs. Corporate enterprises have since made the transition. With the ever expanding role of UAVs, it is only appropriate that NASA make the transition, too.

In addition to these topics, NASA Range Safety is keeping a close watch on the collision avoidance process with respect to impact probabilities and miss distances, changes in range architecture, and frequency management issues and concerns. NASA Range Safety continues to work these issues to better understand the rationale behind each potential change and incorporate items in the NPR based on sound technical judgment while staying attuned to our dynamic environment.

For more background and information on the NPR 8715.5 Revision, *click here.*

3. Range Safety Launch Support Policy

In previous annual reports, we have focused on how NASA Range Safety implements NASA Range Safety policy and explained the various Memorandums of Agreement (MOA) and launch support policy letters that were developed with the Eastern and Western Ranges in order for NASA Range Safety to adequately support pre-launch, launch, and post-launch activities.

In 2008, NASA Range Safety continued work on developing a change to the Space Shuttle Program (SSP) Launch Commit Criteria (LCC) in an effort to implement the requirements of NPR 8715.5. Emphasis was placed on establishing a shared responsibility for range safety with the 45th Space Wing, establishing a real-time variance process and identifying appropriate countdown risk acceptors. Acceptable risk criteria consistent with the Range Safety Risk Management Plan (RSRMP) for the SSP, vehicle tracking, and command requirements are also being added. Furthermore, we worked with the 1st Range Operations Squadron to update mandatory criteria for the Range Safety Display System for Flight Operations Version 1 (FOV 1). The resulting proposed LCC Change Notice (LCN) is being worked through the Space Shuttle Range Safety Panel.

Additionally, NASA Range Safety has been working an update to the KSC PLN 2804, *John F. Kennedy Space Center Range Safety Landing Implementation Plan for Space Shuttle and the Landing Implementation Plan*, and to KSC PLN 2805, *John F. Kennedy Space Center Range Safety Risk Management Plan for Launch and Landing of the Space Shuttle*, into a single document which includes the addition of Ares 1-X acceptable risk criteria.

We are coordinating a review of our current MOA with the 45th Space Wing which is scheduled for its triennial review in February 2009. During this review process, we will jointly determine the applicability of each piece of the agreement and make updates and/or deletions where necessary. Our initial Range Safety MOA with the 30th Space Wing is still being coordinated through Vandenberg Air Force Base leadership. We expect this MOA to be signed in early 2009.

We have also been very active in the development and implementation of tailored requirements for the Constellation Program for both Ares 1-X and Ares 1 as delineated in other included articles. Throughout 2009, we will continue to focus on the preparation of Launch Commit Criteria for Ares 1-X that allows shared responsibility of range safety requirements as described in AFSPCMAN 91-710 and NPR 8715.5.

For more background and information on Range Safety Launch Support Policy, *click here.*

4. Range Safety Group

For more background and information on the Range Safety Group, *click here.*

a. Range Commanders Council Range Safety Group Recap

The Range Commanders Council (RCC) was founded in 1951 to provide a way for DoD test ranges to communicate and discuss problems common to all test ranges. Until this year, NASA was an Associate Member of the RCC with representatives on 6 of the 14 RCC working groups. In the 24 July, 2008 RCC meeting, NASA provided a detailed presentation of their research, development, and test capabilities and applied for full membership. The RCC unanimously approved the request, and NASA became an official voting member.

The RCC Range Safety Group (RSG) continues to provide a forum in which ranges can standardize, develop, and improve on a variety of subjects and processes related to range safety. Range Safety representatives from NASA HQ, KSC, DFRC, and WFF actively support the RSG and its subcommittees on a regular basis. The RSG chair for 2008 was from DFRC, and the new vice chair for 2009 is from WFF. There were two RSG meetings in 2008, summarized below.

b. 102nd Range Safety Group Conference

The 102nd RSG conference was hosted by the 30th Space Wing, Vandenberg Air Force Base, in Santa Maria, CA. The RSG main committee and Flight Termination Systems Committee (FTSC) met. The Directed Energy Range Safety Committee (DERSC) and the Risk Committee (RC) did not meet.

In the main committee, special presentations were made by NAVAIR Pax River (UAV Incidents and Range Safety Criteria for UAVs); NASA DRFC (State Diagram for Standard FTS Tone Receivers), and Mantech SRS (Reusable Launch Vehicle Launch and Reentry and Non-reusable Reentry Safety Requirements). The latter presented issues and concerns for the re-write of AFSPCMAN 91-710 and 91-711. These presentations were followed by Range Reports from each range.

Some of the topics discussed in the FTSC were the Enhanced Flight Termination System (EFTS) program update and status, various Autonomous Flight Termination System briefings, advanced high voltage ordnance initiation systems, a Subminiature Flight Safety System (SFSS) update, and commercial off-the-shelf software in ground transmitter systems. Special presentations were also made by several vendors in attendance, including Ensign-Bickford, ATK Launch Systems, Honeywell, and ABSL Space Products.

c. 103rd Range Safety Group Conference

The 103rd RSG conference was hosted by Navy SCORE (Southern California Offshore Range) in October. It was held in San Diego at the Naval Air Station North Island Naval Base, Coronado. The RSG main committee and FTSC met; the RC and DERSC did not.

In the RSG main committee, Navy SCORE gave an excellent briefing on their facilities and operations, which includes the nations largest underwater test range. Wallops Flight Facility also gave an in-depth presentation and discussion on the recent ALV-X1 failure at WFF, which included a successful activation of the Flight Termination System (see the WFF status report for more information on this event). These presentations were followed by the standard activity reports from each range.

The main topic at the FTSC was EFTS. Several Ranges presented their implementation plans for EFTS and the timeline associated with this endeavor, including Eglin Air Force Base, Edwards Air Force Base/Dryden Flight Research Center, White Sands Missile Range, China Lake, and Point Mugu NAVAIR Pacific. The FTSC also discussed the various RCC documents that would need to be developed or updated to include EFTS. RCC 319, *Flight Termination Systems Commonality Standard,* would have to be revised and updated to include EFTS. Three documents would most likely have to be created to cover specific EFTS topics: an RCC integrated requirements document that the EFTS program has developed; a second RCC document, the EFTS receiver specification that the EFTS program developed with L-3 Cincinnati Electronics; and finally, the test standard for EFTS receivers, similar to RCC 313, *Test Standards for Flight Termination Receivers/Decoders*.

The FTSC and EFTS program also assigned range identifiers to each test range. These range identifiers are part of the EFTS command message that is sent to the vehicle. Each range has a range ID that is used during operations and each receiver has this range ID loaded into it for verification. This prevents a range from inadvertently terminating a nominal vehicle operating on another range.

The Risk Committee did not meet at either of these conferences because they were awaiting approval and funding for task proposals from the executive committee. Prior to the October RSG in San Diego, the Risk Committee received approval and funding for three tasks:

1. An update to RCC 321-07 to include detailed guidelines on treatment of uncertainty in risk assessments and recommendations for evaluating catastrophic risk

2. An update to RCC 321-07 to include conditional risk guidelines and criteria

3. An update to RCC 321-07 to include specific actions for asset protection

5. Air Force and Federal Aviation Administration Common Standards Working Group (AF/FAA CSWG)

Link from areas identified below for AFSPCMAN 91-710, 91-711, and Code of Federal Regulations Title 14, in folder (to date 91-712 not out)

For more background and information on the Air Force and Federal Aviation Administration Common Standards Working Group, *click here.*

a. Reusable Launch Vehicles (RLV) Requirements

The AF/FAA CSWG RLV Sub-Group was formed in April 2006 to initiate the development of public safety requirements for the launch, reentry, and recovery of reusable launch vehicles. The group completed initial development of public safety requirements and sent the updates out to industry for comment. We spent approximately three months dispositioning comments and providing responses to industry. The estimated completion of manned RLV requirements (via incorporation into AFSPCMAN 91-710) is CY 09. Additionally, the group worked RLV requirement inputs for AFSPCMAN 91-711, which will be the focus once AFSPCMAN 91-710 RLV requirements are complete.

As new and emerging space launch technologies surface, the CSWG will continue to provide a forum through which the Air Force, FAA, NASA, and other government agencies can communicate. The goal of this group has been, and will always be, to maintain public safety in all phases of launch activities while developing and implementing common range safety standards.

b. AFSPCMAN 91-710 Update

Air Force Space Command Manual 91-710 (AFSPCMAN 91-710), *Range Safety User Requirements* specifies range user launch safety requirements. It was distributed to industry, NASA, and AFSPC organizations for review and comment in an effort to update the current July 2004 version. Consolidated comments to the plan have been received, with the review and update process scheduled to being in early 2009.

c. AFSPCMAN 91-712

HQ AFSPC/SE will revise and combine the computer and software requirements for range users (currently in AFSPCMAN 91-710) and the computer and software requirements for range operators/acquirers into a single document, Air Force Space Command Manual 91-712 (AFSPCMAN 91-712), *Launch Safety Software and Computing System Requirements*. AFSPC convened an AF/FAA CSWG Software Sub-Group to develop and coordinate these requirements. The draft computer and software requirements were sent to industry, range users (including NASA), and range operators/acquirers for their review and comment. HQ AFSPC/SEC continues the process of reviewing and dispositioning these comments. Both the AF and FAA want to ensure that the software requirements remain common between the two agencies. Currently there is no projected release date for this document.

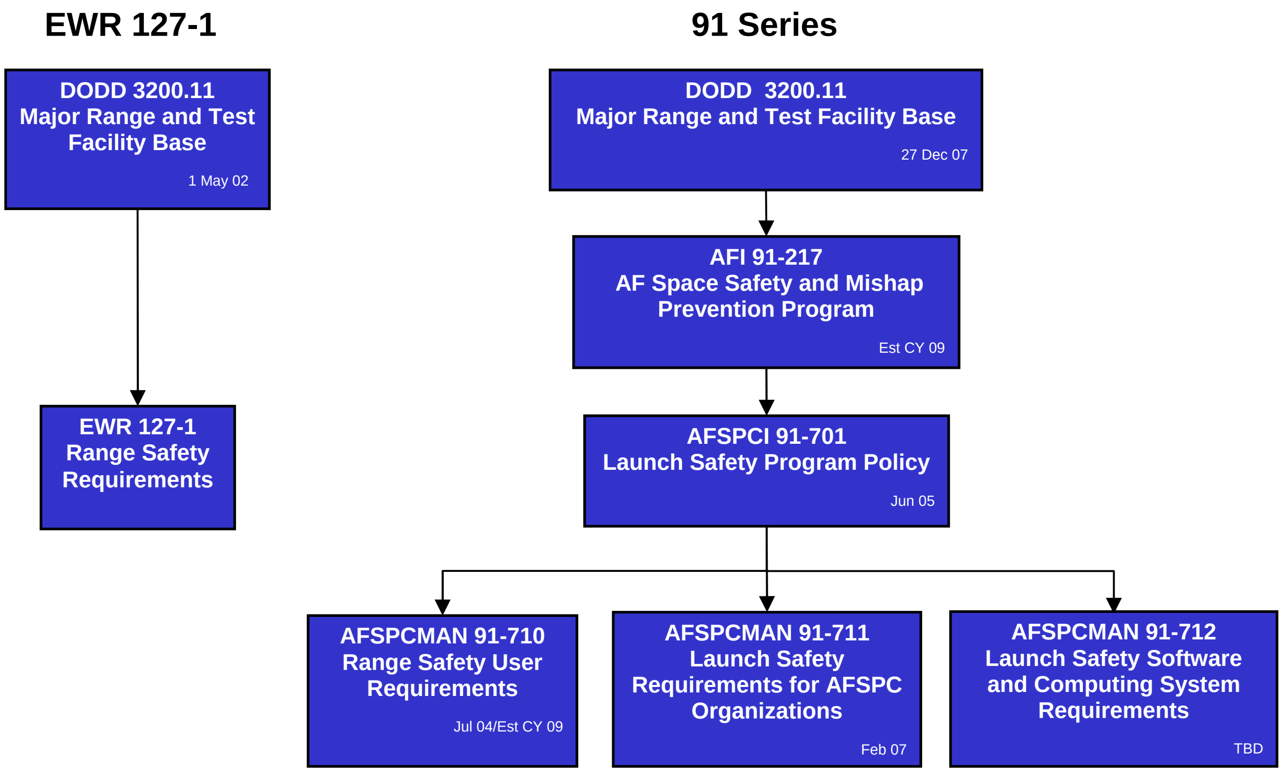

FIGURE 6: TRANSITION FROM EWR 127-1 TO THE 91 SERIES

6. Unmanned Aerial Systems Working Group (UASWG) Policy Development Update

For more background and information on the UASWG Policy Development Update, *click here.*

a. An Evolution Trending Towards Revolution

Unmanned Aerial Systems (UAS) is a technology evolving at an increasing pace. During the last two decades, there was a gradual evolution in the field from drones and Remotely Piloted Vehicles to Unmanned Air Vehicles (UAV). In the 1990s, the technology accelerated to include consideration of the entire flight system – the unmanned aircraft, the command and control links, the ground control system, the navigational inputs, and the controller. By 2000, such flight systems had evolved into network-centric and mature systems vital to fulfilling our national needs. These flight systems encompass a wide range of UASs, including hypersonic vehicles, rotary wing hover systems, lighter than air systems, and various hybrid vehicles. Included in this group are vehicles ranging in size from full scale aircraft down to vehicles the size of houseflies. All are considered UASs since they are controlled by computer programs or the pilot is not on board.

As the technology advances, UASs will soon be operating at all altitudes of the atmosphere and beyond, and it is now difficult to distinguish any difference between an unmanned re-entering Reusable Launch Vehicle and an Unmanned Aerial System.

In 2005, the NASA Range Safety office, the NASA Applied Technology Directorate, and the USAF 45th Space Wing Range Safety office formed an Unmanned Aerial Systems Working Group (UASWG) to address the range support and range safety issues for such diverse systems operating near the launch head of the Eastern Range.

b. Development of Range Safety Requirements

Since 2005, a major technical thrust has been the development of range safety requirements specifically designed to the unique risks at the Eastern Range for unmanned aerial system operations near the launch head. Such challenges include rocket plume effects upon unmanned aerial system flight hardware, additional risks from unmanned aerial system accidents impacting highly volatile rocket propellant facilities, and the application of risk management principles for the safety of personnel and public in relatively close proximity.

During past efforts to address these challenges, the UASWG conducted an extensive document review (2005-2006) to identify subtopics to be addressed in a requirements document and a flight operations manual. Upon the completion of the document review, an outline was developed and sections were assigned to personnel to construct requirements. The rapidly evolving operational concepts and current considerations for operating unmanned aerial systems in the National Airspace create challenges in the development of range safety requirements. In 2007, the safety risk management process was significantly refined in order to address mature operational unmanned aerial systems.

During 2008, the Common Standards Working Group (CSWG) composed of members from Air Force Space Command, NASA, Federal Aviation Administration, and the commercial spacelift industry, worked diligently to rewrite Air Force Range Safety Manuals and AFSPCM 91-710 and 711 to mitigate risks to public safety from the reentry of reusable launch vehicles. Efforts from the NASA-USAF UASWG were useful for these reusable launch vehicle operations. Terminology and paradigm differences between the aviation and rocketry communities were recognized and resolved by the creation of a “Flight Safety System Rosetta Stone.” Paradigms for unmanned aerial system flight safety systems are now being applied to reusable launch vehicle re-entry flight safety systems and risk-based safety requirements for manned and unmanned ballistic, aerodynamic, and buoyant flight operations are approaching consistency.

c. Operational Priorities

Prior to 2008, large unmanned aerial system operations at Cape Canaveral AFS and Kennedy Space Center were not considered appropriate since they generated unwarranted risks to high priority national launch head assets and were an unnecessary hindrance to the primary mission of launch operations. This viewpoint changed with the DoD “Big Safari” Program in 2008, which involved several days of Predator B (aka Reaper) landing and takeoff operations from the Cape Canaveral Air Force Station Skid Strip.

To accommodate the goals of Big Safari, Air Force Range Safety developed range safety practices for the program using concepts developed in the draft Unmanned Aerial Systems Range Safety Requirements Document. Air Force Range Safety arranged flight patterns to avoid overflight of “risk multipliers” or launch head assets that would generate significant secondary risks if impacted by a flight accident. Air Force Range Safety established “Ditch Sites” at the end of every flight pattern leg and prior to the Skid Strip approach to safely terminate the flight if critical vehicle control performance parameters could not be confirmed.

Big Safari was conducted during and in close proximity to ongoing preparations for a Delta II launch without hindrance or unacceptable risk to either operation.

Currently, support for other large, mature DoD and Department of Homeland Security unmanned aerial systems is being considered, and the possibility of home-basing is being assessed. As requests are received for UAS operations of varying maturities and risks, further attention must be given to addressing safety critical technical challenges and configuring an approach for team responsiveness.

d. Technical Challenges

Two major technical challenges came to the forefront this year. First, determine how to manage relatively mature Unmanned Aerial Systems within one or two orders of magnitude as reliable as traditional manned aviation systems. Second, determine how to recognize and certify critical Flight Safety Systems that are not standard from a traditional ballistic launch vehicle perspective but utilized in manned aircraft flight test.

e. Managing Mature UASs

The Big Safari operational support brought the first operationally mature unmanned aerial system to CCAFS, initiating the technical challenges introduced in this section. To evaluate the actual maturity of the UAS, a maturity assessment was made, noting an Air Force-issued Airworthiness Certificate (AFMC Form 273) and taking into careful consideration accident rate data. This posed a challenge, however, as much of the accident rate data is recorded in terms of accidents per cumulative flight hours, whereas primary Launch Head safety concerns need to be addressed in terms of accident rates and cause during take-off, landing, and airfield flight pattern flight modes. Flight time risks during off-shore cruising flight modes confined within special use airspace are managed by procedural control mitigations.

Risks during critical take-off, landing, and airfield flight pattern modes can be identified by first seeking data via a checklist derived from RCC Standard 323. Risks to the public and the launch head can be identified from this data. These risks were significantly mitigated by establishing flight rules establishing flight pattern and flight system health confirmations, coordination of radio and radar interferences, and minimum safe altitudes over critical areas. Emergency procedures were predefined for lost links, ditching, and crash landing. Compliance with Range Safety procedures was confirmed by the presence of a Range Safety Observer in the Ground Control Station (GCS) during critical phases of flight within 30 minutes of takeoff and landing. During all other phases, the Range Safety Observer was readily available.

f. Reorganizing and Certifying UAS Flight Safety Systems

Regarding the second technical challenge, an approach was needed to define broader requirements accommodating alternative, and as yet unforeseen, Flight Safety System options while ensuring public safety.

Many Flight Safety System alternatives are in use throughout the aerospace industry including manned air flight, unmanned aerial systems, precision guided munitions, manned spaceflight, small sounding rockets, re-entry payloads, etc. Flight Safety Systems provide a means of control during flight to prevent hazards from flight vehicles or payloads from reaching populated or protected area in the event of a flight vehicle failure. Flight Safety Systems include all airborne and ground hardware, software, and any human-in-the-loop controls used to protect the public. Human-in-the-loop controls include associated human-systems interfaces and may involve ground-based Mission Flight Control Officers or Range Safety Officers, flight vehicle-based pilots or Flight Safety Officers, or any combination of these elements.

As a Range Safety tool, a Flight Safety System may be used to minimize public safety risk, liability, or emergency management functions. Risk management involves reducing risk to an acceptable level by methods such as destructively terminating flight, terminating thrust, or altering unacceptable vectors or momentum (occasional nudge or flight mode change). Liability management to record and document event outcomes may utilize a Flight Safety System's tracking capability. Likewise, emergency management functions need to know when, where, and how to execute emergency response protocols.

A Flight Safety System may include any or all of the following subsystems depending on the nature of the risks to be mitigated:

(1) Range Tracking Subsystem (RTS) - a method to track the flight vehicle.

(2) A method to receive safety critical status data from the vehicle.

(3) Command Subsystem - A method to either manually, autonomously, or by a combination of both to compare tracking and critical status data to the following established criteria:

- Decide when and if corrective action is required to ensure the criteria is not violated.

- Timely execute the appropriate actions based on the data received or the absence of such data.

- Individuals performing such manual functions may be referred to as Mission Flight Control Officers (MFCOs), Range Safety Officers (RSOs), or Pilots.

(4) A method to affect change to ensure safety criteria is fulfilled, by either:

- Flight Termination Subsystem (FTS) – all components that provide the ability to terminate a launch vehicle's flight in a controlled manner; the flight termination system consists of all command terminate subsystems, inadvertent separation destruct subsystems, or other subsystems and their components that are used to terminate flight.

- Contingency Management Subsystem (CMS) – a method to execute commands to either place the vehicle in a safe or recovery mode or affect real-time corrective actions to resume safer flight.

The reliability of a Flight Safety System is dependent upon the reliability of all components of the subsystems required in the solution to execute a safety control function. This includes components that are ground-based assets; aboard the risk-generating flight vehicle; aboard any other mobile or fixed relay or sensing platforms; inertial, GPS, or any other positional or state-vector determining inputs; software; and the decision making process. Quantifying and confirming attainment of a Flight Safety System's reliability may be a critical and challenging requirement. Therefore these reliability requirements need to be scalable dependent upon the specific risks and the specific risk mitigating solution.

The aviation community continues to express concern over allowing unmanned aerial system flight operations in shared airspace. Some unmanned aerial systems are quite mature, but before they become as safe and reliable as piloted aircraft, technologies must continue to evolve. In pursuit of this goal, attention must be paid to the following:

- A reliable means to "sense and avoid" other planes and obstructions.

- New air-traffic control systems based on electronic rather than voice communications.

- Ability to address and resolve in-flight unmanned aerial system anomalies.

g. Teaming for Responsiveness

In 2005, the NASA Applied Technology directorate initiated the partnership with the Air Force to establish a joint UAS program for UAS operations at KSC, CCAFS, and PAFB with the common goal of meeting identified range mission goals. The need for the establishment of a UAS program was identified by NASA and the Air Force through work encompassed in a NASA-Air Force Memorandum of Agreement (MOA) for setting advanced range technology development goals, and proceeding with next generation technology development and demonstration. This was a NASA Range Safety funded activity.

UAS range functions, as identified by the NASA programs and the Air Force, include UAS:

- To be a relay site between launch vehicles and ground-based operations control centers, providing tracking, telemetry, and launch vehicle commanding.

- To provide rapid responses; tracking and surveillance (i.e., SIGINT, ISR) utilizing thermal, optical, chemical, weather, radar systems.

- To permit real-time, simultaneous monitoring of near-field and far-field zones.

- To provide broadband communication (i.e., IRIS, iNET) extending to large areas.

The NASA-AF UAS range goals will be met by:

- Establishing a NASA-AF UAS Customer Process, UAS Requirements, UAS Concept-of-Operations (CONOPS) for mission support.

- Building a UAS customer base for development and on-site flight demonstrations of instrumentation and systems to meet NASA-AF range CONOPS goals.

- Partnering with Services, Agencies, and Coalition elements to provide the best capabilities for future launches, with the benefit of simultaneous mission needs and cost sharing.

- Seeking the best technical and operational concept solutions from Defense, industry and academic sources.

The NASA Applied Technology Directorate represented KSC in a new Integrated NASA UAS Working Group (INUWG), the first meeting being held at Ames Research Center in 2008. INUWG, a NASA-wide forum, was established to improve Agency-wide communication and coordination of UAS information, promote integration between NASA and other agencies, mitigate risk to mission, and optimize safety. INUWG members intend to standardize high-level NASA policies and procedures for UAS activity that will effect changes to each centers requirements process. The results of the INUWG will be reported annually to the NASA Inter-Center Aviation Operations Panel (IAOP) Chair and NASA HQ Aviation Management Division (AMD). The NASA-AF UAS initiative will benefit from the INUWG membership through opportunities to share recent changes to FAA-NASA-DoD policies, procedures, and hazard identification summaries.

The NASA-AF Unmanned Aerial Systems Working Group continues to strive for operational robustness to protect personnel, property, other aircraft, and national assets, while enabling new flight systems to operate with appropriately managed risk. As UAS operations and range support become routine, the range safety requirements need to meld, possibly via a Common Standards Working Group subcommittee, to standardize USAF, FAA, and NASA Unmanned Aerial System requirements. Range-unique concerns, avoiding risk to specific high value or hazardous national launch head assets, or conducting critical flight operations within hostile launch exhaust or accident environments could be addressed by such a subcommittee to seek requirements commonality and ability to link to range-specific supplemental requirements documents. Furthermore, such a subcommittee could enable the pursuit of developments for optimized collision avoidance systems and innovative flight safety systems.

7. Flight Safety System Update

For more background and information on the Flight Safety System Update, *click here.*

a. Flight Safety System Challenges

To protect of the public, the local workforce, and property, NASA Range Safety ensures that the Flight Safety System (FSS) associated with the launch vehicle is robust and reliable. NASA Range Safety is often faced with issues that could affect how the FSS functions and operates, and these issues must be vigorously investigated to ensure that the FSS will function properly when activated. Some of the major FSS challenges NASA Range Safety dealt with in 2008 are discussed below.

b. Pyrotechnic Shock Testing Concerns

One of the main test services providing pyrotechnic shock testing was found to be inadequate.

Shock testing is performed on launch vehicle system components to ensure that components and systems will perform nominally during flight. The test levels should envelope the maximum predicted environment (MPE) for that component plus some margin to account for nonnominal flight. There are a variety of different types of shock testing such as beam shock, drop shock, and pyrotechnic shock, as well as several different environmental testing services used to perform this testing.

The pyrotechnic shock test service was found to be inadequate because a digital data acquisition system was being used without the use of an anti-aliasing filter. This caused the reported shock test levels to be significantly higher than the actual shock levels, resulting in an under-test condition.

The magnitude of the shock under-test varied with the specific test setup. For some components, the variation was as much as 20 dB or more at certain frequencies. Since several programs and vendors have their hardware tested at this location, it was determined that this poses a significant problem. Of particular interest to NASA Range Safety were the components located in the vehicle flight termination system. Numerous components were involved and were cleared for flight based on rationale such as design features, subsequent confidence testing, flight history, post-flight testing, and previous qualification and acceptance testing.

Based on these test histories and associated analysis, NASA Range Safety had to make recommendations regarding these components and their ability to function nominally during flight.

c. Constellation

NASA Range Safety continues to work with the Constellation program to ensure that all range safety requirements are met.

NASA Range Safety met with representatives from the Constellation Program, 45th Space Wing Safety Office and contractor personnel to continue the tailoring process of NPR 8715.5, *Range Safety Program*, and AFSPCMAN 91-710, *Range Safety User Requirements*. When finished, this document will be the official joint "Range Safety" document for the Constellation Program.

d. Frequency Concerns

Flight termination systems can be designed to use various frequencies for operation. The frequency used is dependant on the range. Each range has a set of frequencies or a frequency band in which they operate. The Eastern and Western Ranges have operated various programs and vehicles on 416.5 megahertz (MHz) for decades. However, the National Telecommunications and Information Administration (NTIA) recently directed that 416.5 MHz no longer be used for flight termination purposes. In addition to their objection to overcrowding, the NTIA feels that wideband ultra high frequency systems, such as FTS, should be operating in the 420-450 MHz spectrum.

Range users have agreed to migrate to the 420-450 MHz band but have expressed concern that existing hardware has been purchased and implemented for 416.5 MHz use. Therefore, remaining launches already scheduled to use 416.5 MHz have been granted approval, while ultra high frequency systems for all subsequent flights will operate in the 420-450 MHz region. The one exception for the Eastern Range is the Space Shuttle Program. This program has a waiver to operate on 416.5 MHz through 2010. If Shuttle does not fly out by this date, another waiver will be requested.

Another concern with transitioning to the 420-450 MHz region is that some high powered radars located at various installations operate in this frequency band. Some of these radars, such as the PAVE PAWS radar, have proven they can indeed interfere with the flight termination receivers located on the launch vehicle.

The Eastern and Western Ranges have mitigation actions in place to coordinate range operations with the various installations using PAVE PAWS to ensure that no interference occurs. One long term solution to this problem is migration to another frequency band where these radars do not exist. The Range Commanders Council Frequency Management Group has put in an official request for use of the 370-380 MHz band for FTS operations. As of this writing, no decision has been made.

FIGURE 7: PAVE PAWS RADAR

For more information *click here* for last year's article.

e. Emerging Technology Development

NASA Range Safety continues their involvement with emerging technology such as the Enhanced Flight Termination System (EFTS), the Autonomous Flight Safety System (AFSS), Reusable Launch Vehicles (RLVs), Unmanned Aerial Systems (UAS), and Space-Based Range Demonstration and Certification (SBRDC). Through various groups and technical interchanges including the Range Commanders Council Range Safety Group and the Common Standards Working Group, NASA Range Safety has been able to stay fully aware of the various programs and technologies that are being developed and continues to monitor these programs for future use and implementation

C. RANGE SAFETY INDEPENDENT ASSESSMENTS

NASA headquarters conducts independent process verification reviews at NASA Centers and Ranges to ensure, among other things, the mitigation of operational, health, and system hazards. Reviews also include compliance with laws, executive orders, publications and standards, local operating procedures, and special interest items that pertain to the center or range.

In response to this requirement, the NASA Range Safety Manager participated in two independent assessments in 2008: Wallops Flight Facility Range Safety Office and range safety-related activities at Ames Research Center.

Although each audit identified noncompliances and observations, it was noted that both Centers have integrated the NPR 8715.5 requirements into their Range Operations. NASA Range

Safety will track corrective actions based on audit findings. All findings were validated through the use of objective evidence and documented on assessment checklists. Findings were categorized as follows:

- Observation – a condition not contrary to documented requirements but warrants improvement or clarification
- Non-Compliance – failure to comply with documented requirements
- Commendation – a process that is performed extraordinarily well or that would provide significant benefit to other centers or ranges

For more background and information on Range Safety Independent Assessments, *click here.*

1. Wallops Flight Facility Range Safety Office

The first assessment was an Institutional/Facility/Operational (IFO) safety audit at Wallops Flight Facility, conducted from 15-18 July, 2008.

a. Objectives of the Assessment

- Review the status and content of the corrective actions resulting from the 2005 independent assessment of the facility's Range Safety Office.
- Evaluate the following primary areas:
  - Management of the Range Safety Training Program Documentation
  - Management of Range Safety Simulation Responsibilities
  - Range Safety Contingency Action Plans
  - Range Safety Flight Safety Officer Candidates
  - Range Safety Waiver Risk Assessment Process

b. Results of the Assessment

The assessment resulted in a commendation recognizing WFF Range Safety civil service and contractor support in their efforts in helping to develop the Agency Range Safety Operations training course.

The completion of the RSO course was the final installment of an Agency-sponsored Range Safety Training curriculum made available to internal and external customers through the NASA Safety Training Center.

This course is the first of its kind and succeeds where other attempts within the larger range safety community have failed. As a result, this course is being utilized by other governmental agencies (such as the FAA) and has been advertised to the DoD Range Commanders Council community. To date, three courses have been completed. Student feedback has shown that this course is popular and highly valued. A student word-of-mouth campaign has resulted in an increase in interest nationwide from the range safety community. The Agency Range Safety Manager has received some indications that this course is increasingly being looked upon as a building block for a number of training programs. Demand for the course is high enough to require the Agency to maintain a waiting list.

2. Ames Research Center Range Safety Related Activities

The second assessment involved an Institutional/Facility/Operational (IFO) safety audit of Ames Research Center on 22-23 October, 2008.

a. Objectives of the Assessment

- Evaluate Ames Research Center plans regarding the implementation of the policy and requirements of NPR 8715.5, Range Safety Program.
- Evaluate the following primary areas:
  - Range Safety Program Documentation Management
  - Range Safety Training Plan for Designated Range Safety Officers (DRSOs)
  - Range Safety Risk Management Process for Operating UASs
  - Range Safety Flight Commit Criteria for UASs
  - Range Safety Contingency Action Plans for UAS operations
  - Designated Range Safety Officer (DRSO) Candidates
  - Range Safety Risk Management Plan (RSRMP)
  - Range Safety Frequency/Spectrum Management process
  - Range Safety Waiver Risk Assessment Process

b. Results of the Assessment

The assessment resulted in a commendation and a best practice write-up for the ARC Range Safety Officer for his outstanding leadership in establishing and implementing the range safety process for ARC UAS Operations.

During a relatively short tenure, the ARC RSO has developed the structure of a sound range safety process at ARC to expand its UAS Program.

Through these independent assessments, the NASA Range Safety Office maintains the baseline of the range safety organizations, determines the compliance or non-compliance of specific requirements, and monitors all open action items to completion. These independent assessments also continue to highlight exemplary performance and to provide an opportunity to enhance range safety programs throughout NASA.

D. COMMON RISK ANALYSIS TOOL KIT DEVELOPMENT

As required by NPR 8715.5; each range operation (launch or flight) shall undergo a range safety analysis to establish any design or operational constraints needed to control risk to persons and property.

To date, each individual Center has met this requirement by developing analysis tools to estimate risk associated with different hazards. Risk models currently used by the Centers are based on specific Center requirements and/or concerns and developed by Range Safety support contractor according to their areas of technical expertise. Some of the existing models have had peer reviews but have not been subjected to an extensive validation and verification (V&V) process. Most of the models also lack well-defined configuration management requirements and user training programs.

Common Tool Kit Development is an attempt to better manage public safety risk models used by NASA by consolidating development efforts and identifying requirements for proper V&V and configuration management. The goal is to develop and make available to all Centers a suite of accepted models under formal configuration management. Training and certification will be required on performing hazard analysis using these models, the associated physics, and acceptable risk levels. This strategy will eliminate redundant risk model development at multiple Ranges and provide Ranges with expanded capability when necessary to evaluate new hazards. It will also somewhat standardize the analysis process and allow analysts to become well-versed in the standard format of hazard analyses utilized by all Centers.

Greater emphasis is being placed on risk management and the use of rigorously validated and verified risk models as larger and more varied launch programs are introduced, such as ELVs, Reusable Launch Vehicles (RLVs), Reentry Vehicles, and in particular, the Constellation Program. For example, the development of an updated debris risk analysis tool for Constellation (Ares 1) continued during 2008. This task is intended to evaluate the current suite of Space Shuttle/ELV launch area and over flight debris risk models and their associated sub-models to determine how they can be improved and integrated into a government-owned and -operated risk analysis tool. This “tool bench” will have an open systems architecture that will provide economies in upgrading hardware, modifying existing models, interfacing new models when new or enhanced capabilities are required, and sharing physics and data modules between risk models. The tool bench will utilize formal processes for verification, validation, and acceptance (VV&A) as well as configuration management and user training/certification.

A draft requirements document outlining modeling capabilities, VV&A, and configuration management has been completed. Evaluations of existing capabilities and proposals on both system architecture and new physics model development will begin in early 2009. Although initial development will focus on supporting Ares 1 debris risk analysis at the Eastern Range, plans are in place to expand the toolkit capability to include other hazards such as toxics and distant focusing overpressure, other launch vehicles such as ELVs, RLVs and UAVs, other phases of flight (descent), and other Centers and Ranges.

For more background and information on Common Risk Analysis Tool Kit Development, *click here.*

III. SUPPORT TO PROGRAM OPERATIONS

NASA and KSC Range Safety supported seven launches this year: one from the Western Range, five from the Eastern Range including four Shuttle launches, a Pegasus launch from Reagan Test Site, Kwajalein Atoll, and assisted WFF with the inaugural ATK ALV/HyBoLT launch.

In order to ensure the requirements of NPR 8715.5 are met during pre-launch, launch, and post launch operations, NASA Range Safety personnel work side by side with our Department of Defense counterparts in the Eastern or Western Range Operations Control Centers. In order to ensure safe flight and compliance with requirements identified in NASA safety directives, NASA Range Safety personnel ensure any range safety-related activities with the potential to impact NASA launch criteria are relayed to the NASA Safety and Program officials.

As we look forward to 2009, we anticipate supporting numerous ELV launches at both the Eastern and Western Ranges. Additionally, we expect to support five Shuttle missions as well as the Ares I-X Flight Test Vehicle in the spring/summer.

Link to 2007 article

EASTERN AND WESTERN RANGE				
Mission	**Vehicle**	**Launch Site**	**Launch Date**	**Responsible Org**
ISS 1E	STS-122	KSC	2/4/2008	DoD
ISS 1J/A	STS-123	KSC	3/11/2008	DoD
NROL-28	Atlas 5	VAFB	3/13/2008	DoD
GPS 2R19 (M6)	Delta II	CCAFS	3/15/2008	DoD
ICO G1	Atlas 5	CCAFS	4/15/2008	DoD
ISS1J	STS-124	KSC	5/31/2008	NASA
GLAST	Delta II	CCAFS	6/11/2008	DoD
OSTM/Jason-2	Delta II	VAFB	6/20/2008	DoD
Geo Eye 1	Delta II	VAFB	9/6/2008	DoD
IBEX	Pegasus	Kwajalein Atoll	10/19/2008	DoD
COSMO-SkyMed 3	Delta II	VAFB	10/25/2008	DoD
ISS ULF2	STS 126	KSC	11/15/2008	NASA

FIGURE 8: EASTERN AND WESTERN MISSIONS 2008

FIGURE 9: DRYDEN FLIGHT RESEARCH CENTER MISSIONS 2008

Date	Project Name	Mission	Location	Mission Result
01/18/08	X-48B LSV (Blended Wing Body)	Flight # 7	Edwards AFB	Success
01/31/08	X-48B LSV	Flight # 8	Edwards AFB	Success
02/08/08	X-48B LSV	Flight # 9	Edwards AFB	Success
02/29/08	X-48B LSV	Flight # 10	Edwards AFB	Success
03/07/08	X-48B LSV	Flight # 11	Edwards AFB	Success
04/04/08	X-48B LSV	Flight # 12	Edwards AFB	Success
04/17/08	X-48B LSV	Flight # 13	Edwards AFB	Success
04/18/08	Ikhana (NASA Predator B)	Flight # 55; Functional Check Flight	Edwards AFB	Success
04/28/08	Ikhana	Flight # 56; Pilot Proficiency Flight	Edwards AFB	Success
05/06/08	Ikhana	Flight # 57; Pilot Proficiency Flight	Edwards AFB	Success
05/08/08	X-48B LSV	Flight # 14	Edwards AFB	Success
05/08/08	Ikhana	Flight # 58; Functional Check Flight	Edwards AFB	Success
05/14/08	Ikhana	Flight # 59; Fiber Optic Wing Shape Sensing Research	Edwards AFB	Success
05/15/08	Ikhana	Flight # 60; Fiber Optic Wing Shape Sensing Research	Edwards AFB	Success
05/29/08	Ikhana	Flight # 61; Fiber Optic Wing Shape Sensing Research	Edwards AFB	Success
05/30/08	Ikhana	Flight # 62; Fiber Optic Wing Shape Sensing Research	Edwards AFB	Success
06/12/08	X-48B LSV	Flight # 15	Edwards AFB	Success
06/17/08	Ikhana	Flight # 63; Fiber Optic Wing Shape Sensing Research	Edwards AFB	Success
06/19/08	X-48B LSV	Flight # 16	Edwards AFB	Success
06/28/08	Ikhana	Flight # 64; Functional Check Flight	Edwards AFB; R-2508 Complex	Success
07/01/08	Ikhana	Flight # 65; California Emergency Fire Mission	Edwards AFB; R-2508 Complex	Success
07/03/08	X-48B LSV	Flight # 17	Edwards AFB	Success
07/08/08	Ikhana	Flight # 66; California Emergency Fire Mission	Edwards AFB; North and Central California	Success
07/10/08	Small UAS		Edwards AFB	Failure[1]

Date	Project Name	Mission	Location	Mission Result
07/19/08	Ikhana	Flight # 67; California Emergency Fire Mission	Edwards AFB; North and Central California	Success
07/21/08	X-48B LSV	Flight # 18	Edwards AFB	Success
07/21/08	X-48B LSV	Flight # 19	Edwards AFB	Success
07/25/08	X-48B LSV	Flight # 20	Edwards AFB	Success
08/11/08	X-48B LSV	Flight # 21	Edwards AFB	Success
08/11/08	X-48B LSV	Flight # 22	Edwards AFB	Success
08/13/08	X-48B LSV	Flight # 23	Edwards AFB	Success
08/18/08	Ikhana	Flight # 68; Functional Check Flight	Edwards AFB	Success
09/04/08	X-48B LSV	Flight # 24	Edwards AFB	Success
09/11/08	X-48B LSV	Flight # 25	Edwards AFB	Success
09/17/08	Ikhana	Flight # 69; Functional Check Flight	Edwards AFB; R-2508 Complex	Success
09/18/08	X-48B LSV	Flight # 26	Edwards AFB	Early RTB[2]
09/18/08	X-48B LSV	Flight # 27	Edwards AFB	Success
09/19/08	Ikhana	Flight # 70; California Emergency Fire Mission	Edwards AFB; Central California	Success
09/24/08	X-48B LSV	Flight # 28	Edwards AFB	Success
10/06/08	X-48B LSV	Flight # 29	Edwards AFB	Success
10/06/08	X-48B LSV	Flight # 30	Edwards AFB	Success
10/15/08	X-48B LSV	Flight # 31	Edwards AFB	Success
10/16/08	X-48B LSV	Flight # 32	Edwards AFB	Success
10/20/08	Ikhana	Flight # 71; Functional Check Flight	Edwards AFB	Success
10/23/08	X-48B LSV	Flight # 33	Edwards AFB	Success
10/23/08	X-48B LSV	Flight # 34	Edwards AFB	Success
10/29/08	X-48B LSV	Flight # 35	Edwards AFB	Success
10/30/08	X-48B LSV	Flight # 36	Edwards AFB	Success
11/01/08	Ikhana	Flight # 72; Acoustics	Edwards AFB	Success
11/21/08	X-48B LSV	Flight # 37	Edwards AFB	Success
11/21/08	X-48B LSV	Flight # 38	Edwards AFB	Success
11/25/08	X-48B LSV	Flight # 39	Edwards AFB	Success
12/02/08	Ikhana	Flight # 73; Functional Check and Proficiency Flight	Edwards AFB	Success
12/06/08	Ikhana	Flight # 74; Acoustics	Edwards AFB	Success
[1] Single Pilot, Multi-Vehicle Flight. Total loss of one vehicle and associated payload.				
[2] FTS Drogue Chute Bottle Pressure exceeded limit due to temperature inversion at altitude.				

DATE	VEHICLE	ACRONYM	LOCATION	LAUNCH RESULT
1/11/2008	36.243 Terrier-Black Brant	LIDOS (Long-Slit Imaging Dual Order Spectrograph	White Sands Missile Range, NM	S
1/18/2008	40.021 UE Black Brant XII	SCIFER-2 (Sounding of the Cusp Ion Fountain Energization Region-2)	Andoya Rocket Range, Norway	S
3/27/2008	36.226 Terrier-Black Brant	CIBER (Cosmic Infrared Background Experiment)	White Sands Missile Range, NM	S
4/14/2008	36.240 UE Black Brant IX	TIMED SEE Underflight Calibration Experiment (TIMED) - Thermospheric Ionosphere Mesosphere Energetics and Dynamics (SEE) - Solar EUV Experiment	Wallops Island	S
5/1/2008	36.223 UH Terrier-Black Brant	X-ray Quantum Calorime	White Sands Missile Range, NM	S
6/26/2008	39.008 DR Black Brant XI	NGSP (Next Generation Sensor Producibility)	Wallops Island	S
6/27/2008	30.074 NO Orion	N/A	Wallops Island	S
7/14/2008	41.075 GT Terrier Mk70 Improved Orion	Sub-TEC II (Suborbital Technology Experiment Carrier)	Wallops Island	S

FIGURE 10: WALLOPS FLIGHT FACILITY MISSIONS 2008

IV. EMERGING TECHNOLOGY

For more background and information on Emerging Technology, *click here.*

A. RADIO FREQUENCY MONITORING AT KSC

Radio Frequency (RF) Monitoring at Kennedy Space Center (KSC) is a vital function to guarantee a non-interference electromagnetic environment, especially during launch and landing operations, and is identified as one of the 2008 KSC High Priority Technology Needs. NASA and Soneticom, Inc, Melbourne, FL, with funding from the Innovative Partnerships Program (IPP), are installing and field testing a system at KSC to provide enhanced RF monitoring capabilities. The IPP established the Partnership Seed Fund to address barriers and initiate cost-shared, joint-development partnerships. The goals of this KSC/Soneticom partnership include:

- Evaluating a commercial precision geolocation system that will continuously monitor RF activity in the KSC environment.
- Identifying areas that might be detrimental to sensitive payloads and/or equipment.
- Characterizing patterns of RF activity at KSC.
- Evaluating the system's ability to identify and locate long-range/off-shore RF emissions.

This project began in August 2008 with an IPP grant to install a three-sensor test system at KSC (Figure 11) with a team comprised of NASA KT-C and IT-D2-A, Soneticom, and the KSC Electromagnetics Effects Laboratory run by Boeing. The sensors are located at 520 feet on the roof of the Vehicle Assembly Building (VAB), at 45 feet on the roof of the Central Instrumentation Building (CIF), and at 18 feet on the Fire Rescue Training Building. These sensors can monitor frequencies from 30 MHz to 3 GHz in the shaded area shown in Figure 12.

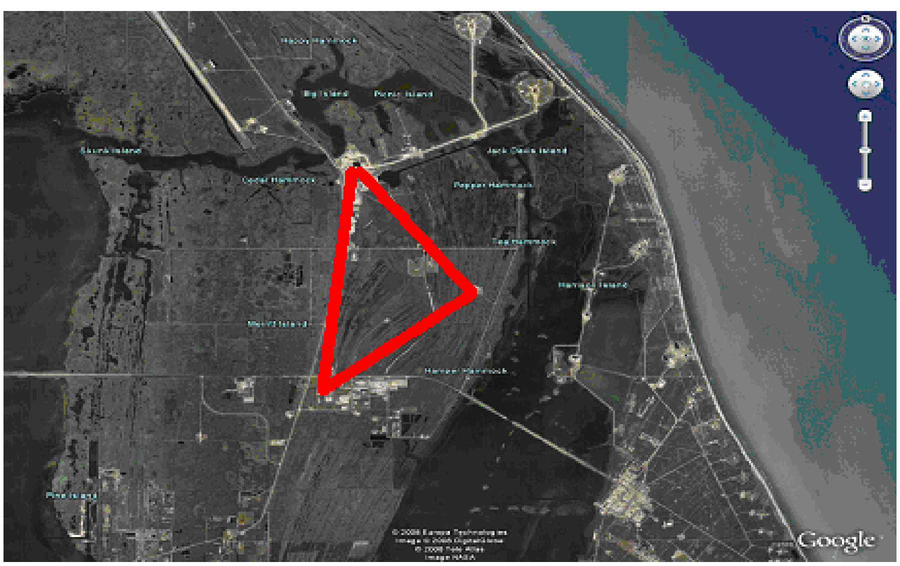

FIGURE 11: SENSOR LOCATIONS

This test system will support a variety of coordinated tests and experiments and will allow different teams at KSC an opportunity to become familiar with the function and capabilities of the precision geolocation system. If funding is available, the long-term goal of this project is to cover all of KSC and Cape Canaveral Air Force Station.

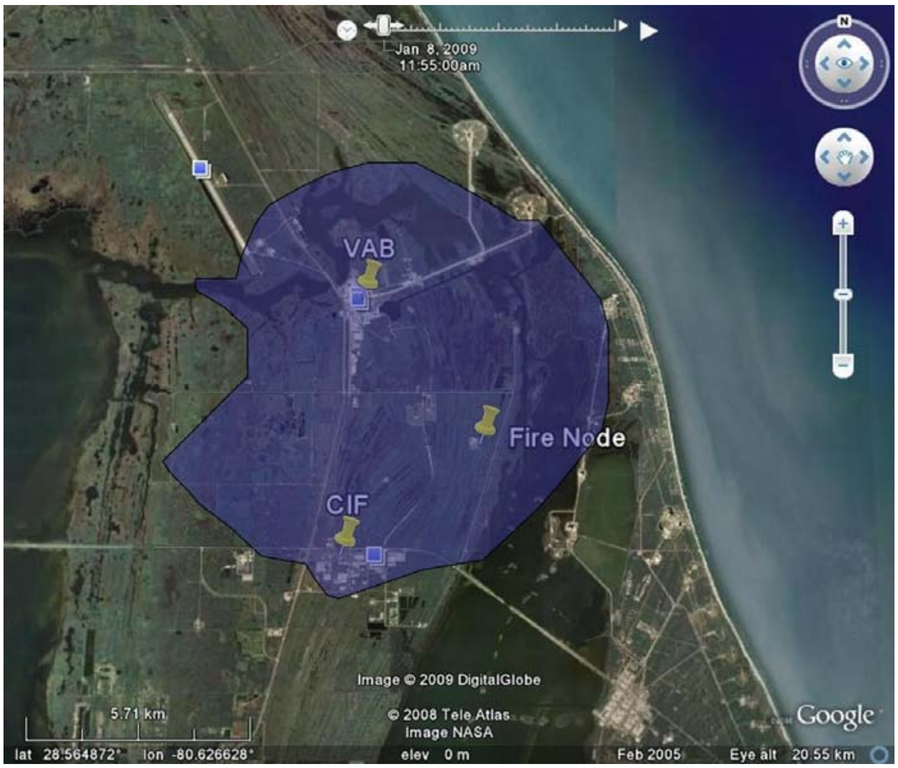

FIGURE 12: THREE-SENSOR COVERAGE AREA

Soneticom currently has two Phase II Small Business Initiative Research projects to provide specialized algorithms and advanced component designs to enhance the RF Monitoring at KSC.

2. GPS METRIC TRACKING UNIT (GMTU)

As the access of space by commercial vehicles continues to be explored and the number of vehicles launching into space increases, the need to incorporate the latest tracking technology becomes a necessity. The tracking technology is the Global Positioning System (GPS), and although it is used in aerospace vehicles today, it has not become mainstream in space vehicles. Instead, technology developed over 50 years ago using ground-based radars is still being used today to track flight vehicles during the launch phase. In response to this need, NASA and the Air Force have agreed to use GPS on all flight vehicles starting in 2011. Therefore, the development and testing of the GPS capability is critical to support the agreement and to support the transition of the GPS capability into future operational systems.

The Applied Technology Directorate of Kennedy Space Center has developed a lightweight, low cost GPS unit called the GPS Metric Tracking Unit (GMTU) (Figure 13) that will move forward the use of GPS systems on space vehicles in the future. This unit was developed under the Space-Based Range Demonstration and Certification (SBRDC) project (formerly known as the STARS project) with a primary goal of advancing range technologies in the area of Range Safety systems.

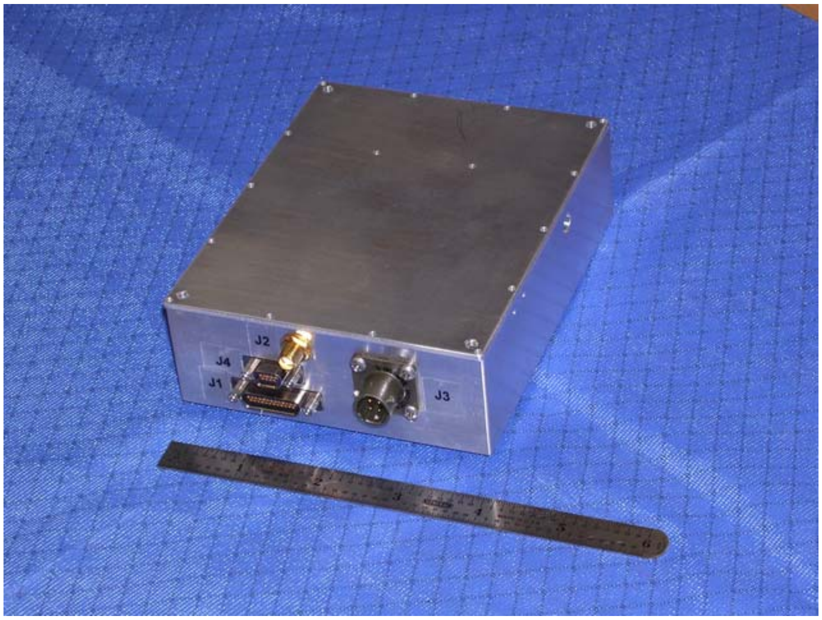

FIGURE 13: GPS METRIC TRACKING UNIT (GMTU)

The GMTU was the first step in a spiral development effort to develop a light weight, low cost. Space-Based Telemetry, Tracking, and Command Subsystem (STTACS) that provides expanded tracking capabilities for the space vehicle community and enhances Range Safety operations. The second step in the spiral development was the Low Cost TDRSS Transceiver (LCT2) developed by the Wallops Flight Facility (WFF). This LCT2 is a light weight, low cost transceiver that can transmit directly to the ground or to a geosynchronous relay satellite.

FIGURE 14: GMTU FLIGHT TEST ONBOARD A SOUNDING ROCKET

Although the GMTU and LCT2 were independently implemented and tested, KSC and WFF engineers collaborated during the development efforts to allow the hardware to be integrated into a single enclosure leading to the final STTACS subsystem.

On 14 July, 2008, the GMTU was successfully flight tested onboard a sounding rocket on a suborbital flight from the WFF (Figure 14). The mission, named Sub-TEC II 41.075/Smith, used a two-stage sounding rocket consisting of a Terrier/Orion booster combination (see Figure 2). The flight was a suborbital flight where the payload parachuted into the ocean and was recovered.

This was the first flight test for the GMTU onboard a sounding rocket.

A second flight test of the GMTU occurred on 7 November, 2008, this time successfully flying onboard an F-104 fighter jet from KSC (Figure 15 and 16).

FIGURE 15: GMTU FLIGHT TEST ONBOARD A F-104 FIGHTER JET

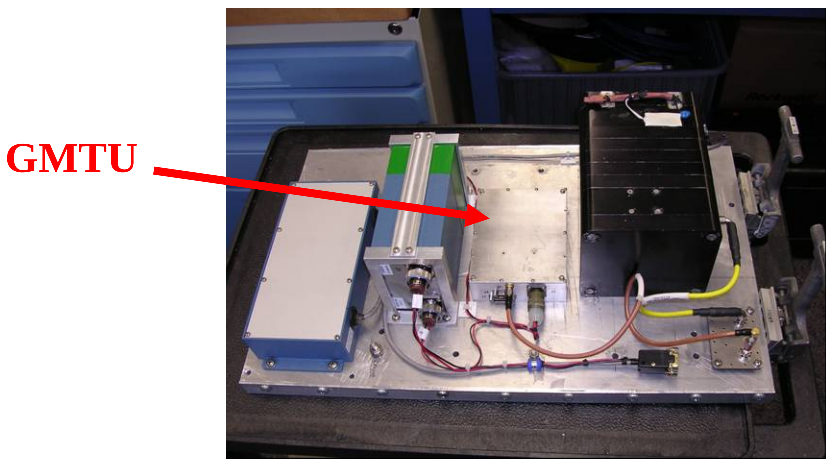

FIGURE 16: GMTU MOUNTED ON THE F-104'S EXPERIMENT PLATE

The GMTU consists of two boards: the KSC designed Command and Telemetry Processor (CTP) board (Figure 17), and the commercially available GPS receiver board. The CTP is the processor board for the GMTU that inputs commands, receives GPS data from the GPS receiver board, and outputs metric tracking data. The CTP was developed using state-of-the-art technologies that allowed a reduction in size from similar previous implementations.

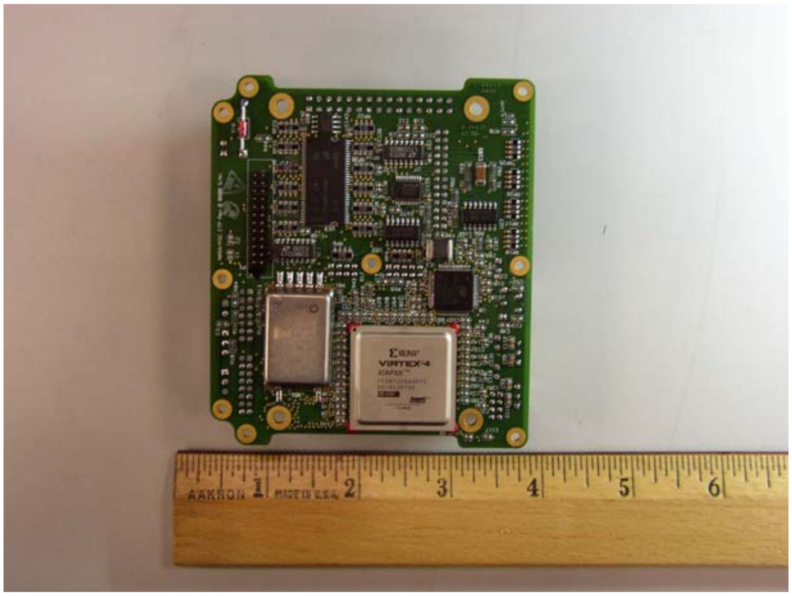

FIGURE 17: COMMAND AND TELEMETRY PROCESSOR (CTP) BOARD DEVELOPED AT KSC

The CTP is a highly versatile, small, lightweight processor board designed for rugged applications and was developed to provide specific functions (namely, the command processing, telemetry processing, and GPS metric tracking of a flight vehicle). It can also be used as a general purpose processor board to perform numerous functions implemented in either hardware or software using the Field Programmable Gate Arrays (FPGAs) two PowerPC processors and/or its logic cells. The CTPs processors run the real-time VxWorks operating system.

Functionally, the CTP was designed for range safety applications that would ultimately be part of a vehicle’s flight termination system. Subsequently, the major functions of the CTP are to perform the forward link command processing, GPS metric tracking, return link telemetry data processing, error detection and correction, data encryption/decryption, and flight termination action command processing. Additionally, the CTP can be used in many applications performing different functions and is not limited to range safety applications. The CTP is a programmable, configurable general purpose processor board that can survive and operate in a launch environment.

The final step of the spiral development will be to integrate and test the GMTU and the LCT2 into one unit. This integrated unit called the STTACS can provide a space-based capability to the flight vehicle to track the vehicle, receive commands, and send telemetry data to the ground directly or through the space-based relay satellite. The STTACS capability onboard a flight vehicle eliminates the need for down range ground stations. The STTACS was designed to meet Range Safety's link margin and latency requirements for vehicle flight termination commands and telemetry.

The GMTU is controlled and configured through a serial or Ethernet interface. For the sounding rocket flight, the serial and Ethernet connections were available in the blockhouse using the vehicle's umbilical interface. Prior to launch, the Ethernet interface was used to verify that the GMTU was functioning properly. Once in flight, the GMTU sent its data to the vehicle's telemetry system which was downlinked to the ground.

The resulting GMTU flight test results will continue to advance aerospace GPS system technologies and architectures. Such technologies help to reduce launch operations costs and provide the flexibility to launch from different areas and for different launch trajectories.

Key accomplishments:

- Successful sounding rocket flight test on 14 July, 2008
- Successfully demonstrated the GMTU in a launch environment
- Successful F-104 flight test on 7 November, 2008
- Successfully demonstrated the GMTU in an aircraft environment
- Continued to increase in TRL and confidence of incorporating GPS technology in aerospace vehicles

Future Plans:

- Integrate and test the GMTU and the LCT2 into one unit called the STTACS
- Pursue efforts to transfer the system into operational use

C. AUTONOMOUS FLIGHT SAFETY SYSTEM

The Autonomous Flight Safety System (AFSS) is a joint Kennedy Space Center (KSC) and Wallops Flight Facility (WFF) project intended for use as an independent and autonomous flight termination subsystem for expendable launch vehicles. It uses tracking and attitude data from onboard Global Positioning System (GPS) and Inertial Measurement Unit (IMU) sensors and configurable rule-based algorithms to make flight termination decisions.

The objectives of the AFSS are to increase capabilities by allowing launches from locations that do not have existing range safety infrastructure, to reduce costs by eliminating downrange tracking and communications assets, and to reduce the reaction time for flight termination decisions.

Previous flight tests have been reported in the annual KSC Range Safety Report. This year the team has been preparing for the flight test of Test Article #3—the third prototype system of the overall AFSS program—on a Terrier Improved Orion sounding rocket at WFF in 2009. The flight test of Test Article #3 will be a demonstration of improvements from Test Article #2 that flew on the SpaceX Falcon at the Kwajalein/Reagan Test Site on 21 March, 2007.

1. Test Article #3

Although Test Article #3 will have a similar hardware configuration as Test Article #2, many improvements and modifications have been made to advance toward the final system. Some of these improvements include:

- A loosely coupled GPS/INS Kalman-filtered navigation solution has been added.
- An improved ground support computer will be used to input the configuration and mission rules files, initialize the system, provide uplinked commands, and monitor the system's performance and software function indications.
- The termination signal output will have a dummy ordnance load that will be monitored instead of only a software flag.
- The team has taken steps to initiate an Independent Verification and Validation (IV&V) of the software including the consolidation of key software design artifacts.
- The AFSS team has been working with the WFF Range Safety office to tailor the Range Commanders Council *Flight Termination Systems Commonality Standard*, RCC 319.
- There are additional input/output ports to the hardware chassis.
- An external lanyard will provide first motion detection.
- The low cost TDRSS Transceiver (LCT2) will provide a forward link to safe the system after the mission is finished and a return link to view the system's performance during the mission.
- An automated test facility has been built at WFF to test GPS receivers, IMUs, and the AFSS.

2. F-104 Flights

The GPS/INS navigation hardware and software was flight tested on an F-104 at the KSC Shuttle Landing Facility (SLF) on 8 November, 2007 and 28 February, 2008. Data was also collected during a flight from Clearwater to KSC on 27 February, 2008. No flight rules were tested. The combined filtered position, velocity, and attitude data as functions of time were compared to the outputs from a GPS receiver and a separate Attitude Heading and Reference System.

A Reimbursable Space Act Agreement, KCA-4143, between NASA KSC and Starfighters, Inc. provided the flight opportunity. NASA-KSC and Starfighters established the partnership to demonstrate the use of the SLF and the F-104 aircraft as a research platform to support NASA's plan for expanding the use of the SLF and to support NASA's project development. Starfighters had an additional partnership with Florida Institute of Technology (FIT) and its Florida Commercial Sub-orbital Research and Training Center. FIT was responsible for the design and fabrication of hardware required for payload installation and interface to the F-104.

The flights provided the opportunity to find and correct several software problems before the upcoming sounding rocket flight of Test Article#3.

FIGURE 18: STARFIGHTERS F104

D. ENHANCED FLIGHT TERMINATION SYSTEM PROGRAM

The objective of the Enhanced Flight Termination System Program (EFTS) is to develop the next generation flight termination system for the Department of Defense and NASA ranges. The program addresses robust command links for flight termination, including message formats, modulation methods, and encryption.

1. Previous Status

The Range Safety Group of the Range Commanders Council initiated a study task and ultimately selected the following:

- Continuous phase frequency shift keying as the modulation scheme
- A 64-bit triple data encryption standard for security
- The layout of the 64-bit message for the new system

The Air Force Flight Test Center then let a contract to build prototype enhanced flight termination receiver decoders and an encoder for the ground transmitter. The receiver decoder and encoder units successfully demonstrated that the enhanced flight termination system would function in flight and in an operational setting.

The Central Test and Evaluation Investment Program (CTEIP) funded the development of the flight termination receiver decoders, encoders, monitors, and encryption units for different range applications, such as unmanned aerial system, space launch vehicles, and missiles. In August 2004, two contracts to develop the enhanced flight termination receiver decoder engineering development units were awarded to L-3 Cincinnati Electronics and Herley Industries. In August

2005, a contract to develop the ground systems (enhanced flight termination system encoder, monitor, and encryption unit) was awarded to L-3 Cincinnati Electronics.

In early 2007, Qualification Testing was completed on three L-3 Cincinnati Electronics flight termination receivers.

In October 2007, the entire system (ground equipment and receivers) was tested at Eglin Air Force Base (AFB) onboard an Advanced Mid-Range Air-to-Air Missile (AMRAAM). The system performed nominally and marked the first live test of the entire system.

2. Current Accomplishments

Milestones accomplished this year are described below.

- The National Security Agency (NSA) has completed the certification of the EFTS units of L-3 Cincinnati Electronics. The two types of EFTS units requiring NSA certification for usage are the flight termination receiver and the ground encryption module (the triple data encryption standard unit). Both the flight termination receiver and the ground encryption module have been certified by NSA.

- With EFTS CTEIP funded development complete, ranges are now working toward implementing and deploying systems to support EFTS.

- NAVAIR at Point Mugu has deployed an EFTS command transmitter system that supports the full Point Mugu range, but the system is not yet operational. This system is currently undergoing independent verification and validation (IV&V).

- NASA Dryden Flight Research Center has deployed an EFTS command transmitter system that supports a single mission (single vehicle), but the system is not yet operational and is also currently undergoing IV&V.

- White Sands Missile Range (WSMR) has begun upgrading to an EFTS command transmitter system.

- Eglin AFB completed its request for information in preparation for a request for proposal for upgrading to an EFTS command transmitter system.

3. Future Plans

The Enhanced Flight Termination System Program will continue to work with various entities to achieve the goals of certifying this system. The program also desires additional testing attempts of the system in 2009 at various ranges.

4. Enhanced Flight Termination System Architecture

The Enhanced Flight Termination System architecture consists of the vehicle and ground systems shown in Figure 19 below. The Enhanced Flight Termination System was designed so that upon the completion and qualification of all units for both airborne and ground systems, implementation with existing architecture would minimally impact the ranges.

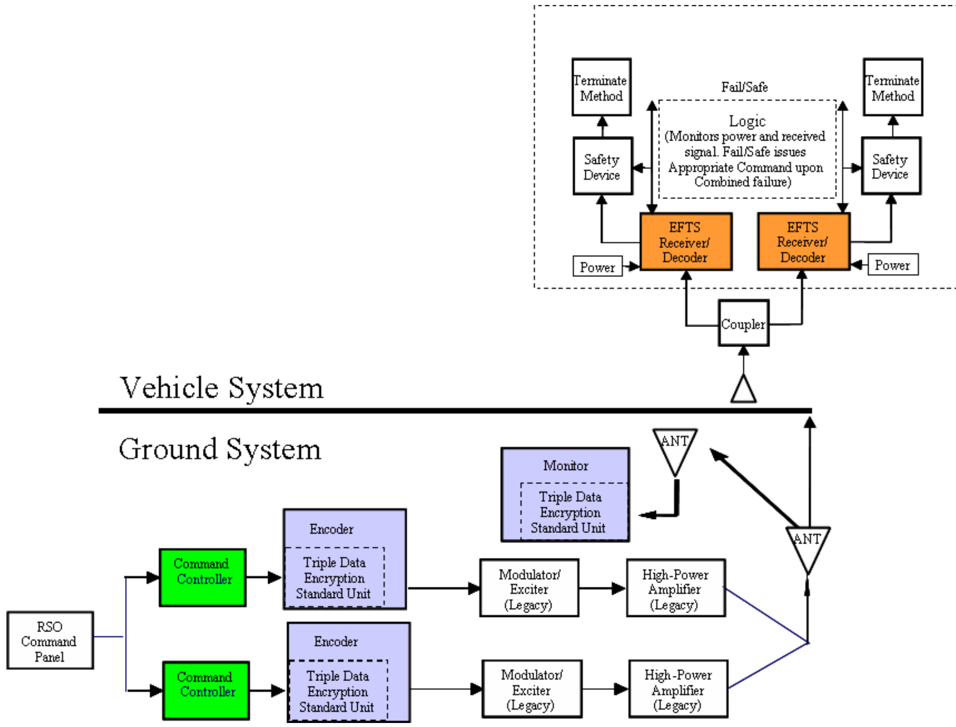

FIGURE 19: ENHANCED FLIGHT TERMINATION SYSTEM ARCHITECTURE

On the airborne side, the Enhanced Flight Termination System uses existing components and systems, where the only new addition would be the new Enhanced Flight Termination System command receiver/decoder. Legacy antennas, couplers, logic units, safety devices, and ordnance will be used along with the new command receiver/decoders and ground equipment.

The ground systems architecture will change somewhat, but the impacts will not be severe. Ranges will have to purchase the new Enhanced Flight Termination System ground equipment (encoders, monitors, and triple data encryption units), and each range can develop the unencrypted 64-bit Enhanced Flight Termination System command frame (command controller) based on its own culture. The ground system will also implement existing technology and equipment including Range Safety Officer command panels, modulators/exciters, high power amplifiers, and command transmitters.

5. Enhanced Flight Termination System Equipment

Four of the major components of the Enhanced Flight Termination System (enhanced flight termination receiver, triple data encryption unit, encoder, and monitor) are described below.

a. Enhanced Flight Termination Receiver

The receiver takes the encrypted messages sent from the command transmitter system (modulator, exciter, power amplifier) and decrypts them into useable commands.

b. Triple Data Encryption Unit

The triple data encryption unit is embedded within the encoders and encrypts the messages using the Triple Data Encryption Standard. A triple data encryption unit is embedded within each monitor for decryption of the Enhanced Flight Termination System message for analysis.

c. Encoder

The encoder takes the encrypted message from the triple data encryption unit and adds a certain amount of frame synchronization and parity bits for forward error correction before sending the final message to the Legacy exciters.

d. Monitor

The monitor is used as an analysis tool for range safety by providing an independent verification process for the transmitted Enhanced Flight Termination System signal. The command transmitter system sends the final encrypted Enhanced Flight Termination System message to the receiver and to the monitor.

The Enhanced Flight Termination System Program has brought a new qualified, improved system to ranges and range users. Outstanding milestones still remain prior to bringing this new system into operational status. NASA Range Safety will continue to work with the Enhanced Flight Termination System Program and support the mission of providing a new advanced method of flight termination that will be low cost and low impact to ranges and range users, while providing a reliable system that will help ensure public safety during launch operations.

E. JOINT ADVANCED RANGE SAFETY SYSTEM

The Joint Advanced Range Safety System (JARRS) is a collaborative effort between Dryden Flight Research Center and the Air Force Flight Test Center at Edwards Air Force Base to develop a state-of-the-art mission planning, risk analysis, and risk management tool for range safety. The Range Safety organizations from all Major Range and Test Facility Bases (MRTFB) are being asked to support the development, testing, and operation of Unmanned Aerial System

(UAS) and Reusable Launch Vehicles (RLVs). It is the vision of JARRS to provide range safety support for these missions.

JARRS consists of two primary elements: a Mission Analysis Software Tool and the Real-Time Operations Tool. The Mission Analysis Software Tool will quantify the range safety risk for a given flight path and its associated vehicle parameters using a computerized method. This method will streamline the range safety analysis by providing a consistent, high fidelity solution in less time than required by present methods of analysis.

Additionally, the Real-Time Operations Tool will provide the Range Safety Officer with near real-time assessment of the range safety risks during flight. This capability has many possible applications to the UAV or RLV operator, including assessment of UAV overflight of populated areas, allowing extended flight of an anomalous vehicle, recovery of an off-nominal vehicle at an alternate landing site, or selection of an alternate flight or entry path.

Major accomplishments this year include a study comparing the probability of impact output from JARSS MP with data from a real-world case, improvements to population/asset management, added the ability to input a simple turn model, and the code was updated to MATLAB 2008a.

V. SPECIAL INTEREST ITEMS

For more background and information on Special Interest Items, *click here.*

A. NASA EXPENDABLE LAUNCH VEHICLE PAYLOAD SAFETY PROGRAM

The Expendable Launch Vehicle (ELV) Payload Safety Program completed the NPR 8715.7, *Expendable Launch Vehicle Payload Safety Program*, on 30 May, 2008 and was approved by NASA Headquarters Office of Safety and Mission Assurance. This NPR contains NASA's policy, roles, and responsibilities, and safety review process requirements for safeguarding people and resources (including flight hardware and facilities) from hazards associated with payloads flying on uninhabited ELVs. The hazards covered include those associated with payload to launch vehicle integration, multiple payloads, and payload-related Ground Support Equipment (GSE). NPR 8715.7 also provides for implementation of Safety and Mission Assurance (SMA) Technical Authority (per NPR 7120.5, *NASA Space Flight Program and Project Management Requirements*) with regard to safety concerns associated with ELV payload projects.

In addition to placing NPR 8715.7 in the NODIS Library, an awareness letter was distributed from Bryan O'Connor, Chief, Safety and Mission Assurance. Introduction roll-out presentations were also provided at the appropriate centers, such as KSC, GSFC, and JPL.

The current draft of the NASA ELV Payload Safety Program Agency Team Implementation Plan contains the roles and responsibilities of the Agency Team in connection with payloads that will fly on ELVs and their associated Payload Safety Working Groups (PSWGs). The purpose and scope of the Implementation Plan is to develop, maintain, and ensure consistent implementation of NASA's ELV payload safety requirements by assisting payload project Payload Safety Working Groups (PSWGs) when needed, providing Agency-wide technical perspective and insight on ELV payload safety-related issues, and supporting SMA Technical Authorities and the Office of Safety and Mission Assurance in matters involving ELV payload safety. It should be completed by February 2009.

The ELV Payload Safety Program is tailoring the AFSPCMAN 91-710 in a joint effort with the Air Force (30th and 45th Space Wings) and applicable NASA Centers (JPL and GSFC). This AFSPCMAN 91-710(T) infuses applicable NASA, industry, and Air Force Range Safety requirements into a single standard for NASA Expendable Launch Vehicle Payload projects. This methodology will ensure a single baseline requirements document that the Payload Project Office will tailor for both Air Force and NASA acceptance and approval. This tailored document should be completed by the Spring of 2009.

B. VAB HAZARD ANALYSIS FOR CONSTELLATION PROCESSING

The Vehicle Assembly Building (VAB) is currently sited for processing a maximum of 16 Shuttle Solid Rocket Booster (SRB) segments. Constellation Program Planning calls for the processing of the Crew Launch Vehicle (CLV), Cargo Launch Vehicle (CaLV), and the Crew Exploration Vehicle (CEV) in the VAB, with the possibility in the out years of having all three vehicles (and perhaps multiple CaLVs) in the VAB at the same time. A study was initiated in 2007 to evaluate and document the Maximum Credible Event (MCE) that could be expected from Constellation vehicle processing in the VAB. The MCE results will be used to support KSC management decisions on viability of existing facilities and personnel in regions around the VAB during the Constellation Program and the need for mitigation and/or new facilities.

In mid-2008, KSC Safety and Mission Assurance Directorate Integration Office (KSC/SA-G) was given the project lead for the overall MCE approach and analyses. KSC range safety personnel were asked to support the team because of their experience and knowledge of available tools for assessing many of the hazards associated with an MCE in the VAB such as toxics, acoustics, and propulsive events. Hazard analyses are focused in six areas shown in the graphic below, with the top four analyses contributing to the Quantity-Distance (QD) Explosive Siting process and all six feeding into the overall VAB risk assessment process.

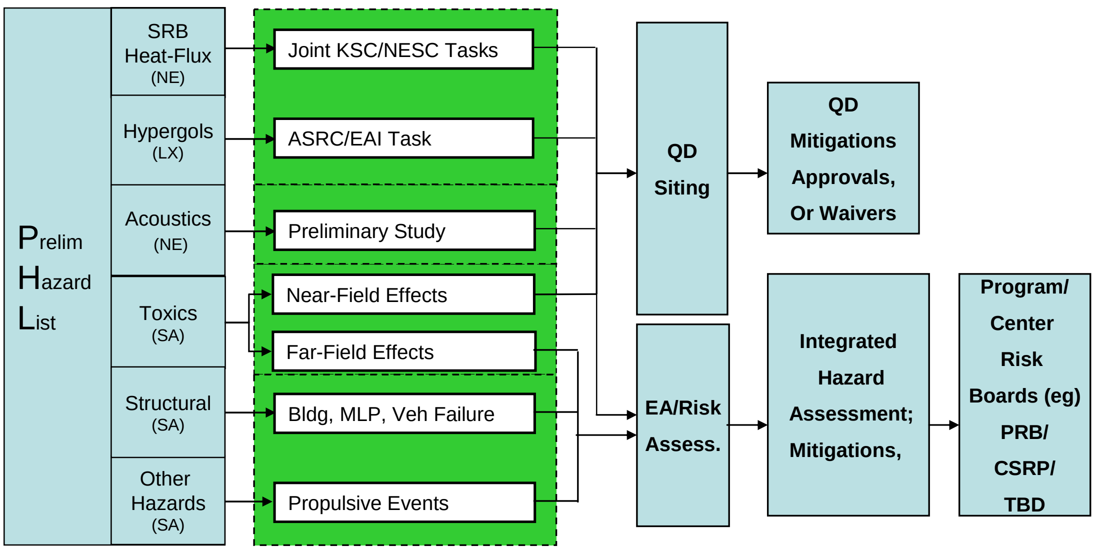

FIGURE 20: HAZARD ANALYSES APPROACH

Specifically, KSC range safety personnel and their contractors were asked to use traditional range safety modeling tools to validate the heat flux and hypergol initial results that were computed on more complex models such as computational fluid dynamics (CFD) and finite elements. Preliminary results from the hypergol blast validation have already influenced the mitigation plans for the VAB and the QD siting approach.

Range safety tools will also be used to analyze the near-field and far-field toxic hazards using inputs from the heat flux CFD runs. The far-field toxic hazard will be assessed with computer models currently used by the Eastern and Western Ranges for launch area risk assessments during ELV launches.

Finally, for the scenario of an SRM propulsive segment or stack potentially thrusting through the VAB roof, traditional range safety tools will be used to assess the risk to the KSC workforce and surrounding public.

KSC range safety personnel will play an important role in many of the individual hazard analyses as well as the overall integrated risk assessment. The hazard analyses should be completed by mid 2011 to support the QD siting process and initial VAB operations for Ares I.

C. LAUNCH ANALYSIS PRODUCTION SYSTEM (LAPS)

The 45th Space Wing (45 SW) operationally accepted replacement systems for the Cape Canaveral Air Force Station's 30-year old Data Processing System (DPS) on 27 October, 2008. The Launch Analysis Production System (LAPS) replaces the pre- and post-mission instrumentation analysis tools that resided on the DPS, and the Safety Hazard Analysis and Risk Processing (SHARP) replaces the flight safety analysis tools used during all phases of mission support.

The 1970s, DPS (Figure 21) was increasingly difficult and expensive to maintain. It consisted of two Cyber 860 mainframes and terminals, located at the Central Computer Complex (CCC), with remote access terminals located at Patrick Air Force Base (PAFB) and the Morrell Operations Center (MOC).

LAPS (Figure 22) was developed for the 45 SW by the Space and Missile Systems Center, Launch and Range Systems Wing (SMC/LRSW), and Spacelift Range System Contract (SLRSC). SHARP was developed by the 45 SW, Launch Safety Office, and their contractor, Millennium Engineering and Integration (MEI).

FIGURE 21: DPS

The development teams, along with the 45 SW, Range Management Squadron (RMS) and Computer Sciences Raytheon (CSR) tested and accepted the long awaited systems.

FIGURE 22: LAPS

Maintenance of the Cyber computers, which filled most of the CCC building at Cape Canaveral Air Force station (CCAFS), was difficult due to 1970-era equipment and parts. There was also increasing fear that major damage to the CCC, such as from a direct hurricane strike or flooding, could have impacted the antiquated equipment.

During the 2004 Hurricane season, CCAFS was battered by hurricanes Charley (direct hit), Frances, and Jeanne. The aging Cyber hard drives failed from temperature instability caused by power outages and from the shutdown process. Approximately seven hard drives failed per hurricane impact, leaving the system without a full set of spares. Without DPS, there would be no instrumentation coverage plans or Range Safety background displays to support Eastern Range launches.

System operators said LAPS is a "tremendous milestone for the ER" and SHARP is a "huge process improvement."

The SHARP project is based upon the Joint Advanced Range Safety System (JARRS) tool bench, originally developed to support Mission Planning for UAVs and High Performance Vehicles. The tools required for the 45 SW Safety analysts to perform the analyses for ER-specific vehicles were added to the tool bench, which has a modern user friendly interface.

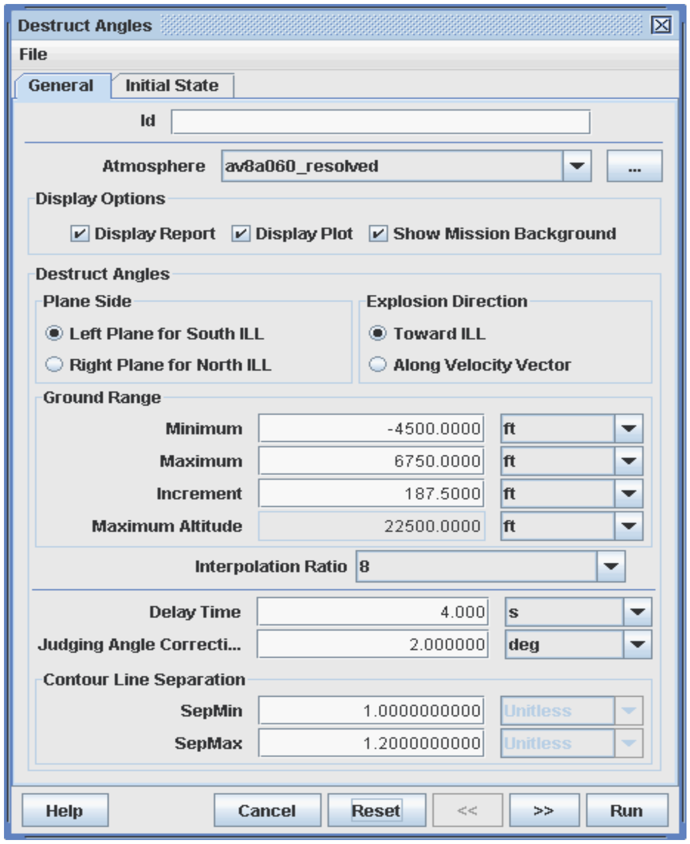

FIGURE 23: USER INTERFACE

Additionally, SHARP produces the outputs required to build backgrounds for the Real-Time Range Safety Displays and the SureTrak Surveillance Display System. Intermediate charts and displays are provided that assist analysts in determining if the products are being generated correctly. Some examples of these displays are provided to illustrate the diversity of these charts and displays.

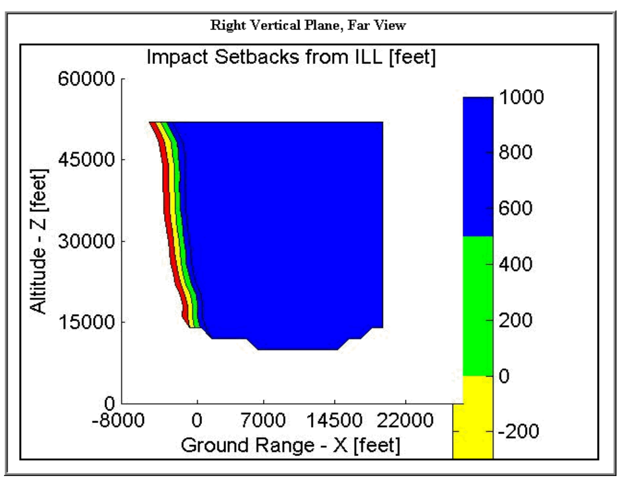

FIGURE 24: DISPLAY EXAMPLE, RIGHT VERTICAL PLANE, FAR VIEW

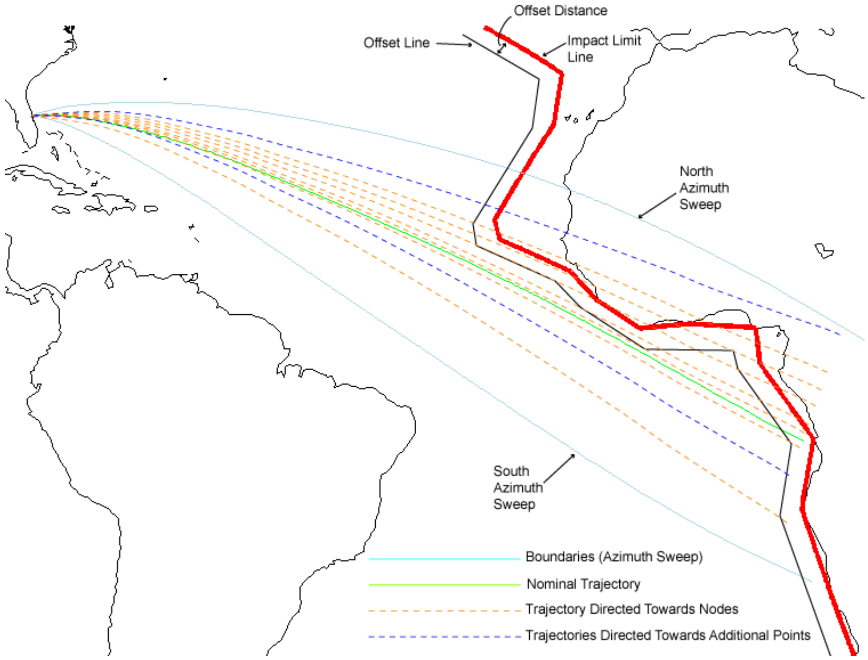

FIGURE 25: DISPLAY EXAMPLE, IMPACT LIMIT LINE

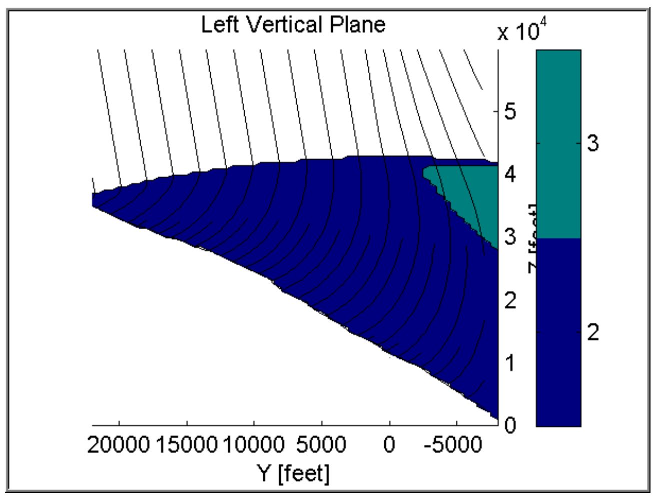

FIGURE 26: DISPLAY EXAMPLE, LEFT VERTICAL PLANE

The new systems are physically smaller, run faster, use standard commercial servers, are modern operating systems, and produce workstation computer products. SHARP is a PC-based system and will execute on any size computer from a laptop to a cluster of processors. SHARP, coupled with LAPS, has increased ER support capabilities to effectively and efficiently launch rockets while ensuring safe access to space.

VI. STATUS REPORTS

A. Kennedy Space Center (KSC)

The Kennedy Space Center Range Safety Representative is tasked with implementing NASA policy and keeping the Agency Range Safety Manager informed of all activities related to range safety. Over the course of the past year, the KSC Range Safety Representative supported a multitude of range safety activities, ranging from prelaunch policy interpretation and guidance to providing on-console support during launch campaigns.

For more background and information on the KSC Status Report, *click here.*

1. Constellation Program

The Kennedy Space Center Range Safety Representative participated in meetings and technical exchange sessions supporting the development of a set of tailored range safety requirements for the Ares 1-X Test Flight Mission. The tailored Range Safety Document, identified as CxP 70155-01, was approved by the Constellation Program Manager, the KSC Center Director, and the 45th Space Wing Commander in late October. The mission will be required to meet both the Air Force Space Command Manual (AFSPCMAN) 91-710, *Range Safety User Requirements* and NPR 8715.5, *Range Safety Program Requirements*. Working through the Launch Constellation Range Safety Panel (LCRSP), the 45th Space Wing Safety Office, Constellation Program Office, and NASA Range Safety successfully developed a single joint tailored document that includes all range safety requirements. This unique teaming process set the groundwork for future tailoring of Constellation Program range safety requirements. The effort also exemplified NASA's philosophy of accepting (or sharing) responsibility for all aspects of range safety. A draft set of tailored requirements for the Ares 1 Launch Vehicle is also underway.

The KSC Range Safety Representative led an effort to prepare a requirements document that will be used to develop a Constellation Program Range Safety Risk Analysis Tool Kit. In 2008, a team consisting of NASA Range Safety, JSC, the 45th Space Wing, and risk model development support contractors completed a requirements draft document that will pave the way for future risk model development. The document includes preferred modeling capabilities but also focuses on verification and validation (V&V) and configuration management requirements. Although the ascent debris hazard assessment capability will be developed first, other hazards such as decent debris, distant focusing overpressure (DFO), and toxics risk are also being considered. The draft requirements document was presented to a LCRSP splinter group in October and received positive feedback.

The Range Safety Representative also provided continued support to the LCRSP and associated Constellation Program working groups.

2. Space Shuttle Program

The KSC Range Safety Representative was involved in the development of an update to the Launch Commit Criteria (LCC) for the Space Shuttle Program Document which will implement NPR 8715.5, *Range Safety Program* requirements. Working through the Shuttle Range Safety Panel, a proposed Launch Change Notice (LCN) incorporating KSC Center Director and Space Shuttle Program Manager responsibilities has been completed, as well as updated acceptable risk criteria. The change is expected to be presented to the LCC Working Group in late 2008 or early 2009.

Launch and entry risk estimates were evaluated for STS-122, STS-123, STS-124, and STS-126, with mitigation efforts initiated through the KSC Emergency Operations Center when appropriate.

The KSC Range Safety Representative also provided continued support to the Shuttle Range Safety Panel and supported STS-122, STS-123, STS-124, and STS-126 launches on console in the Morrell Operations Center (MOC).

3. Launch Services Program

The KSC Range Safety Representative supported a number of NASA expendable launch vehicle campaigns for the Launch Services Program (LSP), including GLAST, OSTM, and IBEX. This effort involved attending all the NASA and Air Force Safety readiness reviews and ensuring NPR requirements were being met during the respective prelaunch and launch countdowns. In 2008, KSC Range Safety became an active participant in the LSP risk boards, presenting items that may increase the public safety risk to the public and workforce.

4. Agency Activities

The KSC Range Safety Representative served as a NASA point of contact to the Range Safety Group and supported committees charged with developing or rewriting nationwide standards on a number of important range safety issues. These topics included developing reusable launch vehicles, unmanned aerial systems, and system requirements. The KSC Range Safety Representative was also active in the development of a proposed policy for the future use of autonomous flight safety systems within NASA. KSC is closely monitoring the status of the AFSPC-proposed decommissioning of Eastern and Western Range ground tracking and command assets through their Future Range Architecture Team.

2008 was a challenging year, supporting a number of launch and entry campaigns, providing critical support to the Constellation Program, continuing to ensure Kennedy Space Center safely implements NASA Range Safety requirements, and tracking emerging technologies. The coming year promises to be equally busy, and the Kennedy Space Center Range Safety Representative will continue to provide critical support where necessary when called upon by NASA programs or to address issues as they arise.

B. WALLOPS FLIGHT FACILITY

Wallops Flight Facility (WFF) had a particularly active and successful year in 2008. The Wallops Safety Office (Code 803) supports all missions at Wallops and also provides support at various other locations around the world as needed. This support includes ground safety and flight safety analysis, documentation of operational rules, and active support of ground processing and flight operations. Listed below are various project/programs that the Wallops Safety Office supports.

For more background and information on the WFF Status Report, *click here.*

1. Sounding Rocket Program

The Sounding Rocket Program (SRP) conducted 9 missions, highlighted by a record breaking launch of a Black Brant XII from Andoya, Norway, which reached an apogee of 1,470 km. Four missions were launched from Wallops including two developmental test flights of a new vehicle based on the surplus M-26 Multi-Launch Rocket System motor and a very successful flight of Suborbital Technology Experiment Carrier (Sub-TEC II) payload, which was recovered approximately 70 miles offshore of Wallops. An additional four missions were successfully launched and recovered from the White Sands Missile Range. The Sounding Rockets program achieved an overall mission success rate of 100% for the missions launched in 2008.

FIGURE 27: SUB-TEC II **FIGURE 28: BLACK BRANT IX**

2. Balloon Program Office

The Balloon Program Office at WFF conducted 14 missions during fiscal year 2008. Flight operations were conducted from Fort Sumner, New Mexico, and McMurdo, Antarctica, in support of Space and Earth Science payloads, as well as developmental test flights for new balloon design and balloon film qualification. Flight durations ranged from 4 hours to 30.5 days with the longest flight occurring over Antarctica. The Balloon Program Office continued the Ultra Long Duration Balloon (ULDB) vehicle development. Flight testing of larger scale designs of the

ULDB is planned for 2009. This balloon is being developed to provide extended duration flights (upwards of 60-100 days) at constant float altitudes.

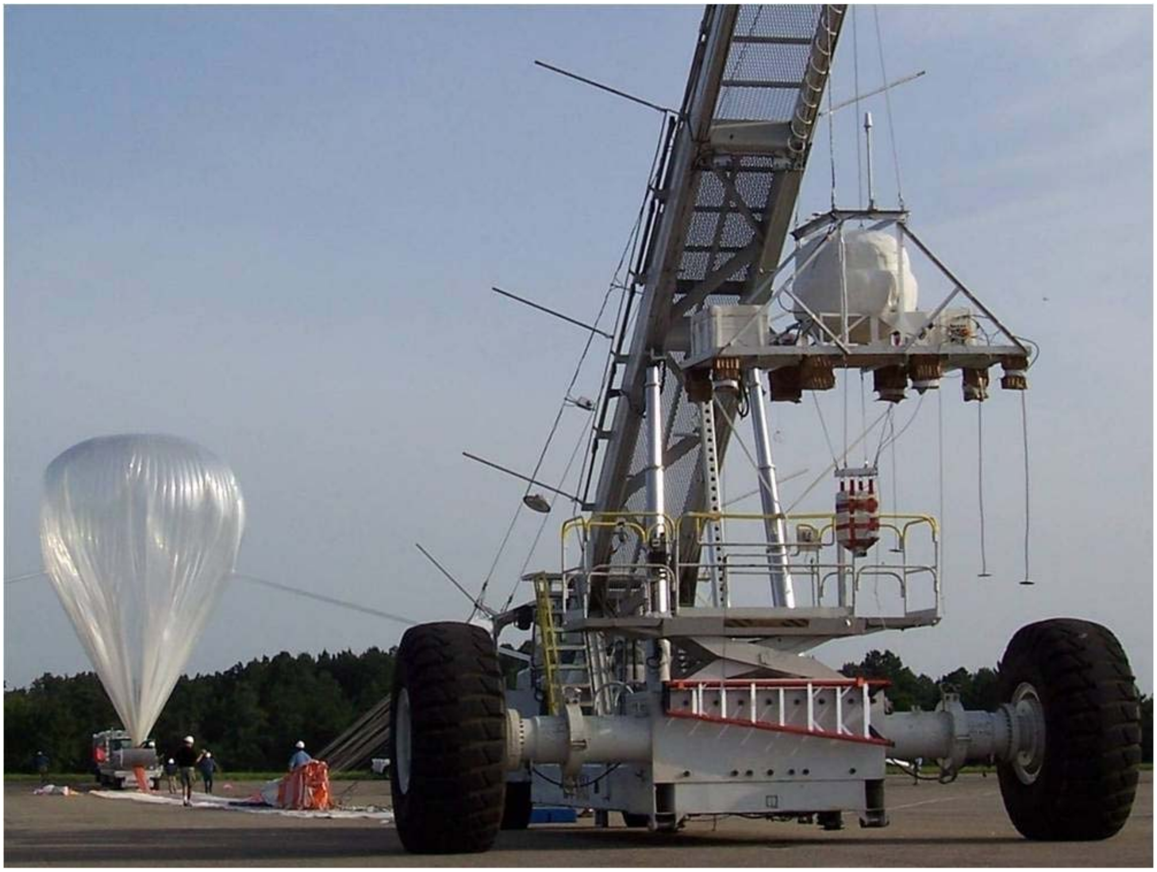

FIGURE 29: TYPICAL BALLOON LAUNCH

3. Airborne Science Program

The Airborne Science Program conducted a series of missions in 2008 using the Wallops P-3B research aircraft including Arctic Climate Change Flights (ARCTAS) over Canada, Alaska, and Greenland from April-July 2008. The ARCTAS mission was the largest of the year, involving flights with multiple agencies and aircraft. The P-3 also flew the Soil Moisture Mapping Validation Experiment (SMAP), which consisted of eight flights flown from Wallops with 100% success in September/October 2008.

In February 2008, the Geostationary Imaging Fabry–Perot Spectrometer (GIFS) mission was flown from Wallops. It is a next-generation geostationary satellite concept for continuous hemispheric imaging of cloud properties, including cloud top pressure, optical depth, fraction, and surface reflectance.

There were four successful P-3 flights in early February off the Atlantic Coast from Virginia to Georgia, with coordinated flights which included CALIPSO underpass flights along with the Langley Research Center (LaRC) B-200 Kingair aircraft. Wallops also continued its hurricane research collaboration with National Oceanic and Atmospheric Administration (NOAA) using the AAI/Aerosonde Unmanned Aerial System (UAS). The Aerosonde UAS (Figure 30) was staged from Barbados with a small group of NOAA personnel on site; however, the storms dissipated so the mission flights will be flown in the future. Many lessons learned were gathered for future hurricane missions with UAS.

FIGURE 30: AEROSONDE

4. Research Range

In addition to internal NASA sounding rocket and UAV missions, the Research Range conducted numerous missions for NASA and non-NASA organizations. The Range launched the HyBoLT/SOAREX payloads for the LaRC on an ATK launch vehicle. Due to still unknown flight issues, the vehicle was safely terminated at 20 seconds into flight. The Range continues to support multiple test and operational UAS flights for NASA, DoD, and commercial entities. The Range supported two missions for the U. S. Navy; the Advanced Modular Gun Demonstrator (AMGD) test firing, which included one ballistic round exceeding 70 nautical miles in range, and a UAS (Navy BQM-74, see Figure 32) low altitude flight.

FIGURE 31: BQM LAUNCH

FIGURE 32: HYBOLT/SOAREX FLIGHT

Wallops continued development of a number of key technologies intended to improve mission capabilities and lower costs. The third test of the Autonomous Flight Safety System (AFSS), incorporating full functional redundancy and integration of GPS and IMU sensors, is scheduled to be performed on a sounding rocket launched from Wallops. The WFF-developed Low-Cost Tracking and Data Relay Satellite System (TDRSS) Transceiver (LCT2) had several successful transmitter flights. Transceiver capabilities have been added and will be included on the AFSS flight.

A new phased array antenna design that offers opportunity for significantly higher data rates on suborbital and orbital launch vehicles was successfully demonstrated on a sounding rocket in 2008, as was a high data rate (~200MB) Ku Band telemetry system, in an effort sponsored by the Missile Defense Agency.

Wallops continues to upgrade many of its safety critical systems. Funding has been received to upgrade the Flight Termination System (FTS) Command Transmitters to allow for the use of High Alpha and/or the Enhanced Flight Termination System (EFTS) secure commanding capability. Testing continues on the latest version of the real-time computer system that provides flight critical data from various radar and telemetry systems. Requirements documentation has begun on a new mission graphics system. Testing continues of a new aircraft and ship surveillance system. Each of these systems requires safety certification prior to use at WFF.

C. DRYDEN FLIGHT RESEARCH CENTER

The Dryden Flight Research Center (DFRC) located at Edwards Air Force Base, California, is NASA's primary installation for flight research and flight testing. Projects at Dryden over the past 62 years have lead to major advancements in the design and capabilities of many civilian and military aircraft.

The Center supports operations of the Space Shuttle and development of future access-to-space vehicles, conducts airborne science missions and flight operations, and develops piloted and uninhabited aircraft test beds for research and science missions.

Range safety operations at Dryden are managed by the Range Safety Office (RS Office). The Office was established by the Dryden Center Director under an alliance agreement with the Air Force Flight Test Center (AFFTC) to provide independent review and oversight of range safety issues. The Office supports the Center by providing trained Flight Terminations System (FTS) engineers, Range Safety risk analysts, and Range Safety Officers to provide mission and project support for Unmanned Aerial System (UAS) Projects. The DFRC/AFFTC Range Safety Alliance allows both RS Offices to work together, each providing expertise on projects the other office may not be as familiar with.

The DFRC/AFFTC Range Safety Alliance plans to install and test a fixed EFTS transmitter site which should be operational by the end of next calendar year.

Dryden continues to support the testing of a wide range of UASs. The UASs that were flown with Dryden assistance include:

For more background and information on the DFRC Status Report, *click here.*

1. Small UASs

Small UASs (sUAS) are in the model-type classification of flight vehicles. Dryden has established an area that offers sUAS Projects a unique opportunity to conduct flights within the restricted airspace. Dryden has also established a streamlined flight approval process for sUASs that makes the airworthiness and safety review quicker and easier than those performed for larger UASs. Dryden has supported over 300 hours of operations on 9 different platforms from 5 different manufacturers.

2. Blended Wing Body Low Speed Vehicle

The Blended Wing Body (BWB) Low Speed Vehicle (LSV) UAS, also known as X-48B LSV, is a dynamically scaled version of the original concept vehicle. The X-48B LSV Project is a partnership between NASA, Boeing, USAF Research Laboratory, and Cranfield Aerospace. The primary goals of the test and research project are to study the flight and handling characteristics of the BWB design, match the vehicle's performance with engineering predictions based on computer and wind tunnel studies, develop and evaluate digital flight control algorithms, and assess the integration of the propulsion system to the airframe. The BWB testing will address several key areas that future aeronautical designs will face, namely noise reduction, emissions reduction, and improvement in fuel economy. Industry studies suggest that because of its efficient configuration, the BWB would consume 20% less fuel than the jetliners of today while cruising at high subsonic speeds on flights of up to 7,000 nautical miles. To date, the project has conducted 39 successful flights.

3. NASA Global Hawk

Dryden has acquired two former United States Air Force (USAF) Advanced Concept Technology Demonstration (ACTD) Global Hawk UASs. These preproduction Global Hawks were built by Northrop Grumman for the purpose of carrying reconnaissance payloads. The vehicles will primarily be used to supplement NASA's Science Mission Directorate by providing a high altitude, long endurance airborne science platform. The vehicle has an 11,000 nautical mile range and 30+ hour endurance at altitudes above 60,000 feet mean sea level (MSL). The first airborne science mission flight is scheduled for Spring 2009.

4. Ikhana

NASA's Ikhana UAV is a General Atomics Predator-B modified to support and conduct Earth Science missions for the Science Mission Directorate. The aircraft is designed to be disassembled and transported in a large shipping container aboard standard military transports. Last year, the vehicle successfully flew multiple missions over the western United States in support of the National Interagency Fire Center. The flights reached as far north as Washington, Idaho, and Montana. Recently, the vehicle has flown multiple successful missions over California wildfires, sending near real-time imagery to the firefighters. The vehicle has also flown multiple flights in support of NASA research, specifically the Fiber Optic Wing Shape Sensing tests and Acoustics tests.

Ikhana has been registered with the FAA and given the tail number N870NA.

The Range Safety Office has supported flight planning and risk analysis tasks in support of FAA Certificate of Authorization (COA) applications as well as real-time operations support. The vehicle has flown 20 flights this year with durations lasting as long as 10 hours.

5. Orion

The Orion Project is an element of the Agency's Constellation Program. The Orion Project consists of the Crew Module (CM) and the Launch Abort System (LAS). Dryden is responsible for conducting a series of flight tests to demonstrate proper operation of the LAS and CM recovery systems in response to abort events initiated on the launch pad and during the initial ascent phase of flight. The abort flight tests will be conducted at U.S. Army's White Sands Missile Range (WSMR) in New Mexico.

Dryden is currently in the process of integrating the Crew Module test article for the Pad Abort 1 test flight. Dryden will also be responsible for integration of the second Crew Module test article for the Ascent Abort 1 test flight. Integration of the crew modules for the remaining flights will occur in the Orion Assembly Integration and Test Facility at NASA's Kennedy Space Center.

The development testing that has occurred in Calendar Year 2008 include two successful full-scale static test firings of the LAS jettison motor and one successful full-scale static test firing of the LAS abort motor. The jettison motor is a solid rocket motor designed to separate the LAS from the Crew Module. The abort motor is a solid rocket motor designed to separate the LAS and Crew Module away from the Ares I launch vehicle in the event of a problem on the launch pad or anytime during first stage burn.

The RS Office tailored NPR 8715.5, *Range Safety Program*, for Pad Abort #1 and provided input to RCC 319, *Flight Termination Systems Commonality Standard* tailoring for Ascent Abort #1.

D. NASA HEADQUARTERS

The Safety and Assurance Requirements Division (SARD) at HQ OSMA provides corporate leadership in the definition and implementation of NASA's Agency-wide Safety and Mission Assurance Policies, Procedures, Standards, Tools, Techniques, and Training. The HQ Range Safety Representative is located within SARD and has oversight responsibilities for the Agency Range Safety and ELV Payload Safety Programs.

The HQ Range Safety Representative and other members of OSMA participated in several primary activities in 2008 in support of the Range Safety and ELV Payload Safety Programs: independent audits of the Agency and local Range Safety functions at Wallops Flight Facility and Ames Research Center; a continuing effort to update NPR 8715.5, *Range Safety Program*; and development and approval of NPR 8715.7, *Expendable Launch Vehicle Payload Safety Program*. The audits were conducted as part of the NASA HQ Safety and Mission Assurance Audits, Reviews, and Assessments Program defined by NPR 8705.6. Numerous proposed revisions to NPR 8715.5 were generated in 2008 by the Agency Range Safety Team. A revised draft document has been developed and will undergo full Agency review in 2009. The HQ Range Safety Representative participated extensively in the development of NPR 8715.7 and was instrumental in its approval on 30 May, 2008.

The HQ Range Safety Representative was directly involved in activities leading up to, during, and after the HyBoLT/SOAREX launch failure at Wallops Flight Facility: served on an Independent Review Team with focus on the Flight Termination System and other flight safety related systems; served on the Range Readiness Review Board; and served on a Special Action Team chartered to conduct a comprehensive review of NASA systems, processes, and performance associated with the launch. The Team verified that NASA followed proper procedures and that the safety systems functioned properly.

Other activities included support to the Range Commanders Council Range Safety Group (RSG), Space Shuttle and Constellation Range Safety Panels, Common Standards Working Group (CSWG), and support to R&D projects such as Joint Advanced Range Safety System, Autonomous Flight Safety System, and Enhanced Flight Termination System (see separate articles on all these projects in this report).

For more background and information on the NASA Headquarters Status Report, *click here.*

E. JOHNSON SPACE CENTER

For more background and information on the JSC Status Report, *click here.*

1. Launch Constellation Range Safety Panel

The Launch Constellation Range Safety Panel (LCRSP) manages launch range safety matters for Constellation program vehicles, including specifying key interfaces with the Department of Defense (DoD) for launch range safety.

This report summarizes the work conducted through the LCRSP and its two chartered working groups.

a. Launch Constellation Range Safety Panel Trajectory Working Group

The Trajectory Working Group (TWG) was the first sub-group chartered by the LCRSP. The primary responsibility of the group is to ensure that each Range Safety trajectory analysis requirement, as specified by the 45th Space Wing, is coordinated among the proper NASA centers.

During 2008, the TWG activities were primarily focused on satisfying range safety requirements for a planned launch of the Ares I-X flight test vehicle in 2009. This effort involved Ares I-X simulation development and comparing the trajectory simulations being utilized at the various NASA centers involved in completing the Ares I-X analysis tasks Also included were activities supporting POST2 (LaRC), MAVERIC (MSFC), and ANTARES (JSC) as an ongoing process of an IV&V effort.

The following official products were completed and delivered for the Preliminary Flight Data Package (PFDP):

(1) Ares I-X 3-Sigma Trajectory Envelopes

These data were created by executing a 6-DOF simulation configured for Monte Carlo analysis using 64 system dispersions. The dispersions sets include aerodynamics, mass properties, sensor errors, propulsion, RSRM thrust vector control, and roll control system thrusters. The vehicle models consist of flight control system, aerodynamic, thrust, and mass properties as of June 2007.

2000 Monte Carlo simulations for each of six wind profiles were executed to compute the six flight envelopes necessary to meet Air Force requirements. East and west wind runs are used to establish the launch area steep (LAS) flight envelope, the maximum instantaneous impact range (MaxIIP) flight envelope, and the minimum instantaneous impact range (MinIIP) flight envelope. The 50 & 230 degree azimuth wind runs are used to establish the launch area lateral (LAL) flight envelope. The north and south winds are used to establish the right and left instantaneous impact point (RIIP/LIIP) flight envelope.

For each flight envelope, determination a single trajectory was identified that closely followed the flight envelope to be used for vehicle debris footprint analysis.

(2) Ares I-X Sonic Boom and Acoustic Analysis

The analysis methods used in generating this data followed the "best practices" as described in NASA SP 8072 and utilized the atmospheric propagation effects as implemented in the Aircraft Noise Prediction Program (ANOPP). These methods were applied to the Ares I-X vehicle flying the nominal ADAC2 trajectory.

The Ares I-X primary propulsion system is comprised of Shuttle legacy hardware consisting of a four-segment solid rocket booster. The propulsion system generates a maximum of 3.1 million pounds of thrust and subsequently 203 dB of acoustic energy. These numbers place the Ares rocket in a category below the Space Shuttle or Saturn V vehicles in terms of an acoustic environment.

The sonic boom and acoustics information delivered was intended for use in both the Preliminary and Final Flight Data Packages unless further analysis by the Range Safety Officer was required or the vehicle or its trajectory undergo substantial modification.

A significant amount of work was also conducted for delivery of the Final Flight Data Package (FFDP) required by the 45th Space Wing early next year:

- Ares I-X Nominal and Malfunction Turn Trajectories including improved malfunction failure mode models. As in the preliminary data delivered in 2007, this dataset will include thousands of trajectories for various credible failure scenarios using updated vehicle models.

- Ares I-X Three Sigma Flight Envelopes developed using the Monte Carlo technique and Space Shuttle trajectory component methodology and updated vehicle models.

NASA centers providing support for these Ares I-X range safety products include Langley Research Center, Johnson Space Center, Marshall Space Flight Center, and Jet Propulsion Laboratory. Representatives from Kennedy Space Center and the 45th Space Wing were also regular participants in the working group and provided technical assistance on many occasions.

b. Launch Constellation Range Safety Panel Probabilistic Risk Assessment Working Group

The Probabilistic Risk Assessment Working Group was first chartered in early 2007 as the forum through which all launch vehicle range safety-related reliability analyses and products would be coordinated for the Constellation Program. This technical forum supports the Launch Constellation Range Safety Panel in all matters related to vehicle failure probability estimation for range safety risk assessments in compliance with the requirements of the Constellation Program, NASA's NPR 8715.5, *Range Safety Program*, and applicable Air Force Range Safety policy and requirements. The members of the working group include representatives from the Launch Vehicle Project Office (Ares, Ares I-X), Mission Operations, Safety and Mission Assurance, and the 45th Space Wing.

The working group completed a number of tasks in 2008 in support of the Ares I-X fight test vehicle. In particular, the group coordinated all tasks pertaining to the final Ares I-X range safety probabilistic risk assessment to be provided to the United States Air Force as part of the Ares I-X final flight data package. The risk assessment was developed by Safety and Mission Assurance personnel at Johnson Space Center, Marshall Space Flight Center, and Langley Research Center.

The Ares I-X range safety risk assessment is a new challenge in that it is a first of its kind vehicle. First flights of vehicles have historically been shown to be significantly riskier than mature vehicles due the unknowns associated with first flight. A new process is being developed by the working group to estimate first flight failure probability based on probabilistic risk assessment (PRA) models which are developed normally to estimate mature system risk. The methodology being developed links the mature vehicle risk estimate from the PRA model to the empirically-derived first flight risk of 0.3 for experienced rocket developers and adjusts the PRA result based on the difference in complexity of the new vehicle to the “generic” vehicle risk of 0.3. The work and collaboration between NASA and the 45th Space Wing on this issue will continue to evolve.

c. Other Topics Considered by the Launch Constellation Range Safety Panel

Many other topics were again addressed this year, including Ares I Debris Catalog, Ares I-X Requirements Tailoring, Range Safety Tools and Modeling, Launch Enterprise Transformation Study, and Errant Launch Abort System

(1) Ares 1 Debris Characterization

Significant progress was made on the Ares I Debris Catalog using a debris risk assessment process. This process is made up of three phases: generating debris risk input data, developing the debris catalog for Range Safety and Orion aborts, and performing the Range Safety and Orion abort risk assessments.

Several factors were identified that define the debris risk assessment inputs needed to conduct a breakup analysis, including malfunction turn failure modes, malfunction turn breakup estimations, aerodynamic breakup characterization, failure mode identification (explosive, non-explosive), and upper stage and service module reentry rupture data.

24 debris catalogs have been initially estimated when vehicle configuration and breakup modes are considered for each flight event.

(2) Ares I-X Requirements Tailoring

Tailoring of CxP 70155-01, *Ares I-X Range Safety Requirements* document, developed through the Launch Constellation Range Safety Panel, has been completed and approved by the Steering Panel (45th Space Wing Commander, the Constellation Program Manager, and the KSC Center Director).

This single tailored document combines the baseline requirements of AFSPCMAN 91-710 and NPR 8715.5 for Ares I-X.

Volume 1, *Range Safety Policies and Procedures*, along with Volume 2, *Flight Safety Requirements*, and Volume 4, *Airborne Flight Safety System Design, Test, and Documentation Requirements*, were the focus of the tailoring effort.

A request by the 45th Space Wing Commander to identify major departures from the current AFSPCMAN 91-710 requirements was addressed along with the public safety waiver approval process.

Four Range Safety waivers to AFSPCMAN 91-710 requirements were proposed to eliminate major cost and schedule impacts where the public safety risk is considered very low.

(3) Range Safety Tools and Modeling

A special Range Safety Tools and Modeling meeting was held in October to define simulation and processing models that are required to support Range Safety tasks, poll the agencies (NASA, 45th Space Wing, and industry) for possible model sources, and to create a roadmap for acquiring and developing the resources to support Ares I-Y and subsequent projects. The goal of this exchange of information was to leverage off of work done and use available resources where requirements permit.

Stake holders in this effort are the 45th Space Wing who ensure public safety, NASA Range Safety community who provide required data to the 45th Space Wing, and the Constellation Elements who conduct abort and crew risk studies.

This face to face meeting also provided the opportunity for the range safety community to share information on the tools, processes, and analyses that could be used in the *Cx Debris Risk Assessment Process.* This process will be used to create the Ares 1 debris catalogs and perform Range Safety and Orion abort risk assessments.

(4) Launch Enterprise Transformation Study (LETS)

Air Force Space Command (AFSPC) is proposing radical changes to the launch range infrastructure and operations to reduce operating costs. The Launch Enterprise Transformation Study (LETS) seeks to determine the cost and mission impacts if GPS Metric Tracking (MT) followed by an Autonomous Flight Safety System (AFSS) is required by all range users.

The AFSS is an independent subsystem mounted onboard a vehicle that uses onboard tracking and telemetry to make Flight Termination System (FTS) decisions. These decisions are based on redundant independent sensors used to determine vehicle state (position, health, and status) and apply software-based flight rules.

Radars will be reduced to a single modernized Radar Open-System Architecture (ROSA) radar at each launch head and manned ground-based flight termination systems (FTS) will be eliminated. These changes are expected to be phased in from 2010 through 2018.

The Constellation Program is preparing a response to these changes through the Launch Constellation Range Safety Panel (LCRSP). The GPS MT capability is expected beginning with Ares I-Y. There is no program impact expected, although a certification effort will need to be addressed. Constellation may have requirements beyond one launch head radar to track the first and upper stages, so the ability of single ROSA radar to interrogate two different beacons must be understood.

NASA has taken the preliminary position that AFSS may be used only after a significant period of operational use on larger expendable launch vehicles and only in conjunction with man-in-the-loop decision making on the ground. The human decision and the AFSS must agree for a destruct command to be sent. This operational concept meets NASA human error tolerance requirements by requiring two independent decisions for flight termination.

(5) Errant Launch Abort System

Early in the Abort Flight Test (AFT) program, the Flight Test Office determined that the size of the Orion abort motor was such that an evaluation would be required to see if a flight termination system (FTS) would be required. Addition of an FTS is undesirable from a project standpoint due to additional development and certification activity with significant cost.

The worst case scenario regarding safety from a range standpoint would be an inadvertent separation of the Launch Abort System (LAS) at or near abort motor ignition. It was decided that establishing the maximum range for an “errant LAS” would be a conservative boundary for establishing the launch pad location. The following Orion LAS scenarios were assessed:

- Tail Feather scenario, where the LAS inadvertently separates at T=0. Analysis exhibited stable flight and resulted in a down range distance less than 4 nm.

- Broken Tail Feather scenario, where a complete failure of all the LAS/CM connections results in fly-away LAS without the CM. Analysis exhibited stable flight, and all cases have a downrange distance less than 4 nm.

- Broken Pencil scenario, assuming a complete failure of LAS abort motor/adapter cone field joint. This failure results in fly-away LAS without the CM or adapter cone.

Analysis resulted in marginally stable to unstable flight. A couple of cases out of thousands exceeded 4 nm, indicating this failure scenario has a very low probability of occurring.

After an independent assessment by Mantech, under contract to the KSC Safety Office, the WSMR Flight Safety Office accepted the Errant LAS analysis and concurred that FTS was not required. A 4 nm radius exclusion zone was established for the Pad Abort missions and LC-32E was approved as the launch site.

This report addresses many of the highlights from a very active year for the LCRSP. We are very fortunate to have such a high level of cooperation, focused productivity, and commitment demonstrated by this diverse community, including the 45th Space Wing and multiple NASA centers with their contractor teams.

2. Space Shuttle Range Safety Panel

During 2008, the Space Shuttle Range Safety Panel addressed several topics including the new launch conjunction process, low inclination public entry risk, solid rocket booster (SRB) beacon availability requirements, the Space Shuttle external tank (ET) entry assessment, SRB recovery ship positioning procedure changes, and launch and landing program requirements document updates. The following provides a summary of each of these topics. Also included is a list of Shuttle Range Safety Panel accomplishments for 2008.

a. Space Shuttle Launch Conjunction Process

In 2008, the Shuttle Range Safety Panel began an effort to define the Shuttle Program response to the United States Air Force (USAF) Special Instructions (SPINS) which direct that all launches out of the Eastern and Western ranges will be screened against the entire USSTRATCOM debris catalog. SPINS provides latitude for this screening allowing the use of either miss distance or statistical Probability of Collision (Pc) computations to determine times during the launching vehicle's launch window when unacceptable conjunctions are present. These times would be used to enact cutouts in the launch window.

The Range Safety Panel and the Joint Space Operations Center (JSpOC) are responsible for performing the conjunction analysis and have begun to define the process for Shuttle launches and identify issues that may result from the screening. NASA's primary concern was that the specified 25 km spherical miss distance would produce a large number of cutouts for objects that were not a threat to the Orbiter, since the uncertainty in the Shuttle insertion vector is much better understood than other launch vehicles. To minimize this concern, the Range Safety Panel and JSpOC recommended to USSTRATCOM that the Pc and miss distance criteria that will be used for Shuttle launches be the same as the criteria that are currently contained in the Shuttle flight rules for pre-launch conjunction evaluation.

Additionally, to facilitate this process, Shuttle data will be reformatted into the input format for the JSpOC program that will run the conjunction computations, an analysis will be completed to estimate the expected number of cutouts, and the logistics of handling cutouts that are produced in the firing room will be defined. The USAF is also planning two launches of DoD payloads that will serve as test cases for the new pre-launch Collision Assessment (C/A) process. This process will not be implemented at the ranges until these test cases are complete.

b. Space Shuttle Low Inclination Public Entry Risk: Flight Rule A2-207 and NSTS-60561 Updates as a Result of Hubble Space Telescope (HST) Servicing Mission

Public entry risk analysts assessed the collective risk for the due east launch of STS-125 Hubble Space Telescope servicing mission. The analysis revealed that approximately 23% of the entry opportunities to the Kennedy Space Center (KSC) landing site would be excluded because of the following wording in NPR 8715.5:

> "The assessed collective public risk for Space Shuttle entries shall not exceed the highest risk associated with the ascending entry trajectories into Kennedy Space Center (KSC) from the International Space Station orbit inclination of 51.6 degrees."

The maximum collective risk for the HST mission to KSC is 2370x10-6 casualties per entry while the highest risk from a 51.6 degree orbit inclination, and therefore the maximum allowable casualties per entry, is 1800x10-6. Approximately 23% of HST trajectories exceeded the 1800x10-6 limit.

A collaborative effort between the Space Shuttle Program (SSP), NASA Headquarters (HQ), and the Office of Safety and Mission Assurance (OSMA) to revise and expand the collective public risk policy resulted in NASA Interim Directive (NID), NM8715-66. This revision used the same approach that was taken in developing the original policy for the 51.6 degree trajectories. The addition to the policy allows the SSP to use KSC as its primary landing site for the HST servicing mission, and, as with the ISS mission policy, it establishes a public safety risk threshold to be used when considering alternate landing sites. Concurrently, the NSTS-60561 Range Safety Risk Management Plan for Entry of the Space Shuttle Orbiter document was updated to reflect the 2370x10-6 expected nominal end-of-mission for STS-125. An STS-125 flight rule annex, FR 125_A2-99, was also submitted to outline changes to placards (for 51.6 degree missions) listed in generic FR A2-207, Landing Site Selection. All of the proposed document modifications submitted were approved. Finally, the onsite risk to each continental US landing site workforce and its visitors was evaluated, and range safety personnel at each site were informed of any changes. Impacts to the sites as a result of this analysis were minimal.

c. Solid Rocket Booster Beacon Availability Requirements

The Shuttle Range Safety Panel addressed the conflict of a Range Operations Supplement requirement for a single functioning solid rocket booster (SRB) beacon with the NASA-accepted Shuttle Launch Commit Criteria (LCC). The SRB beacons provide two advantages:

1. Reliable and robust radar tracking off the pad and during possible catastrophic events.

2. Allows for a delay of flight termination action after a vehicle breakup in first stage to protect the Orbiter when both beacons are operational (per the Range A4-258.C.3 flight rule).

Radar skin track alone is not committed for the first 12 to 15 seconds of flight leaving only optics tracking. However, SRB beacons provide good radar tracking off the launch pad. The Panel agreed that the first 12 to 15 seconds of flight is likely the period of highest public risk and that a SRB beacon will help minimize public risk during this critical period. Additionally, requiring a SRB beacon would allow the Mission Flight Control Officer (MFCO) to delay destruct action after a first stage breakup as they could continue to track the individual SRBs.

The Shuttle Program classifies the SRB beacons as a Crit 3 system with no redundancy on a single SRB. Therefore, requiring both beacons be functional could result in a launch scrub if a single beacon fails prior to launch. Since a launch scrub also provides risk and is more likely than a vehicle breakup scenario, the Range Safety Panel concluded that one beacon should be required and a two beacon requirement was not warranted.

d. Space Shuttle External Tank (ET) Entry Assessment

During the ascent of STS-114 in 2005, a piece of foam was observed shedding from the ET. The Space Shuttle Program (SSP) later decided that tanks should be manufactured without Protuberance Air Load (PAL) ramps in order to reduce the risk of ET debris during ascent. Until tanks could be manufactured without PAL Ramps, all the existing tanks required the PAL Ramps to be removed. The associated ET design changes involved ET TPS thickness which affected ET rupture altitude, a driver in the ET debris footprint size. Mean ET rupture conditions for each of these tanks were assessed against the Shuttle Program requirement documented in Volume X (3.3.3.2.8.5) Mean ET rupture requirement of 249 kft.

New Mean ET Entry trajectories (based on a DI-122 nm mission) were generated in 2006 which provided relief in the nominal mean rupture altitude and yielded acceptable mean rupture conditions. When all of the PAL-Ramp-removed tanks were flown, Shuttle missions utilized tanks manufactured without the PAL Ramps. The DI-122 ET Entry trajectories were re-screened in 2008 to determine if they were applicable for future baseline tanks (manufactured without PAL ramps). The analysis indicated that the original DI-122 ET Entry trajectories were applicable for future tanks and also showed that new entry trajectories would provide thermal relief for the tanks if needed in the future. Based on these results, new DI-122 ET Entry trajectories were delivered for use on International Space Station missions (51.6 degree inclination, DI-122 nmi) that use an ET designed without PAL ramps. The analysis also confirmed that the generic ET entry trajectories already in Volume X (DI-170 nm set) are still applicable for all missions.

e. SRB Recovery Ship Positioning Procedure Changes

Shuttle Solid Rocket Booster (SRB) recovery ships for STS-118 were positioned further south cross-range than is optimal due to insufficient information needed to correctly interpret the Day of Launch (DOL) dual pane launch window. Prior to launch, SRB recovery ships are generally positioned at coordinates, specified by the Surveillance Control Officers (SCOs), for the launch window open (LWO) or in-plane launch time. The in-plane time is often the middle of a 10 minute planar window. However, for STS-118 the dual pane resulted in a launch window of approximately 11 minutes and the recovery ships were incorrectly placed for the in-plane position of a 10 minute window. Additionally, changes from the in-plane time were not appropriately provided to the SCOs to calculate the final ship position. To correct these issues the Launch Countdown (LCD) procedure S0007 was updated so that the Flight Director will pass the in-plane time for the first pane to the NASA Test Director at L-1H30M, and any launch deltas measured from the in-plane time will be passed from the Landing and Recovery Director (LRD) to the SCO for use beginning with STS-120.

f. Launch and Landing Program Requirements Document Update for Jimsphere and AMPS

The Launch and Landing Program Requirements Document (L&L PRD) which represents the formal agreement between the Range and the Space Shuttle Program, lists the jimsphere and AMPS (Automated Meteorological Profiling System) balloon based wind and atmosphere measurement systems as "MANDATORY" for launch. As documented, the Range is required to be NO-GO for launch in the event of a balloon system failure. However, these systems are only required for launch support by the MCC launch and landing assessment teams until about two hours prior to launch. A checkpoint was added to the Loads and DOLILU Officer (LDO) timeline to assess the requirement for the balloon systems at approximately launch minus two hours. If sufficient data has been received from the Range to assess the launch and landing environment, the LDO will notify the Ascent Flight Director (AFD) that the AMPS and Jimsphere balloon systems are no longer "MANDATORY" for launch. The AFD will relay the release of these systems to the NASA Test Director (NTD), who in turn will relay the change in status to the Range. Failure of the balloon systems after this point will not result in an automatic "NO-GO" condition for the Range.

g. Summary of other 2008 Shuttle Range Safety Panel Accomplishments:

- Revised the NSTS Directive Number 42B: *Space Shuttle Program (SSP) Range Safety Management Charter*.
- Proposed LCN update to LCC A4-258.C.3 to state NASA's requirement for one of two SRB beacons for launch.
- Updated the NSTS 60561, Rev. A, *Range Safety Risk Management Plan*.
- Created a NASA Interim Directive (NID) NM8715-66 for the NPR 8715.5 entry range safety policy update for STS-125.
- Updated Flight Rule FR A2-207, *Landing Site Selection,* to reflect the entry range safety policy for STS-125.

- Proposed major updates to KSC's Risk Management Plan, KSC PLN 2805.

- Updated the S0007 checklist with a new step to release the L-1 hr weather data from "mandatory" to "required."

SUMMARY

Range Safety was involved in a number of exciting and challenging activities and events in 2008 involving the development, implementation, and support of range safety policies and procedures. Notable activities include the joint tailoring efforts between the Program, the 45th Space Wing, and the Launch Constellation Range Safety Panel supporting the Constellation Program; progress toward codifying updates to AFSPCMAN 91-710, 91-711, and 91-712; and the continuing development and implementation of policies supporting the Unmanned Aerial System program. Range Safety also initiated and nears completion of a revision of NPR 8715.5, *Range Safety Program*, to accommodate developments in our evolving discipline.

Range Safety representatives also took part in a number of panels and councils, including the Launch Constellation Range Safety Panel, the Space Shuttle Range Safety Panel, and the Range Commanders Council (RCC) and its subgroups. Until this year, NASA was an Associate Member of the RCC with representatives on 6 of the 14 RCC working groups. At the 24 July, 2008 RCC meeting, NASA petitioned and was unanimously approved as an official voting member.

Advancing our effort to provide training at various levels of range safety, 490 students participated in the 19 courses conducted in 2008. Additionally, NASA and KSC Range Safety supported seven launches this year consisting of one from the Western Range, five from the Eastern Range including four Shuttle launches, a Pegasus launch from Reagan Test Site, Kwajalein Atoll, and assisting WFF with the inaugural ATK ALV/HyBoLT launch.

Range Safety also participated in the evaluation of several emerging technologies, including RF monitoring at KSC, GPS Metric Tracking Units, and the Autonomous Flight Safety System. The Enhanced Flight Termination System continues to advance, with ranges now working toward implementing and deploying the system. The Joint Advanced Range Safety System has also made progress toward achieving its goal of supporting Unmanned Aerial Systems and Reusable Launch Vehicles at all ranges.

We hope you found our web-based format for the Range Safety Annual Report to be usable and informative, and we hope that linking to the original articles has reduced the need for repetition in this report without sacrificing the quality of the information presented. As we move into 2009, we look forward to the opportunities and challenges of ensuring the safety of NASA activities and operations. Anyone having questions or wishing to have an article included in the 2009 Range Safety Annual Report should contact Rich Lamoreaux, the NASA Range Safety Program Manager located at the Kennedy Space Center, or Michael Dook at NASA Headquarters.